WEATHER BASICS

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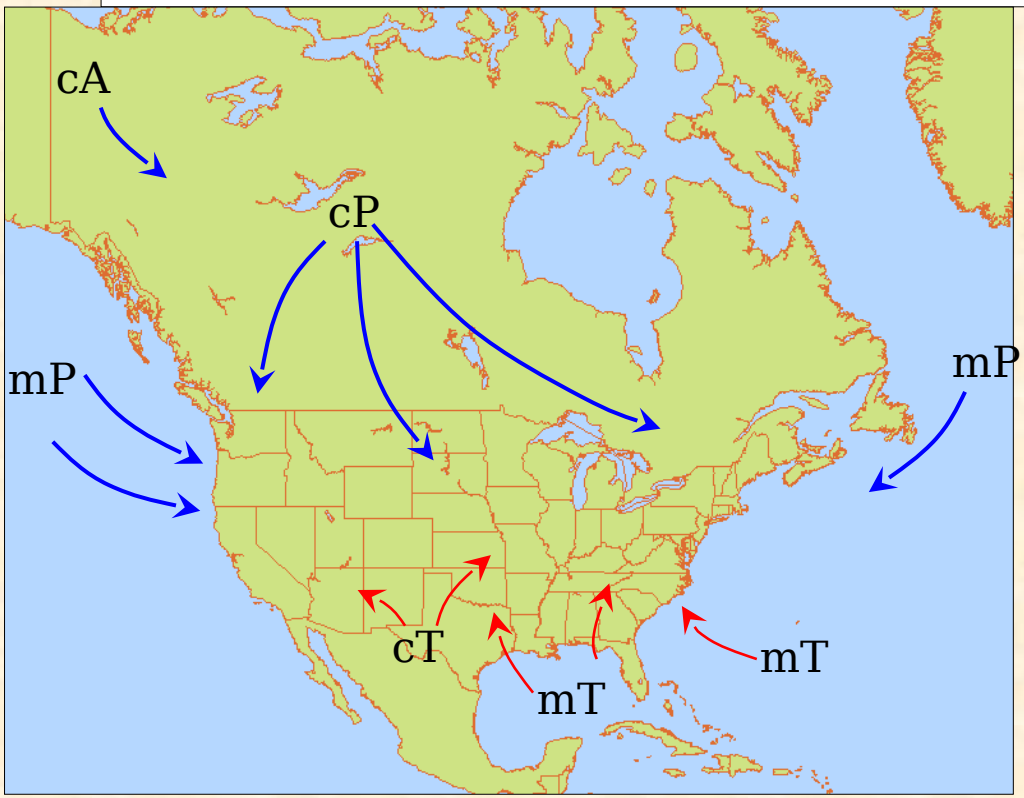
TOPICS COVERED

- AIR MASSES
- FRONTS
- PRESSURE SYSTEMS
- CLOUDS / CLOUD FORMATION
- FOG
- ICING
- TURBULENCE
- LOW LEVEL WIND SHEAR
- THUNDERSTORMS
- MICROBURSTS
- TORNADOES
- TROPICAL WEATHER

Air Masses

Air masses are large bodies of air that are approximately homogeneous in their horizontal extent with respect to temperature and moisture characteristics.



Air masses are classified by where they originate (their "source region").

Example:
First letter:
c - continental
m - maritime

Second letter:
P - polar

Necessary Conditions for Air Mass Formation

- A surface whose properties (temperature and moisture) are relatively uniform.
- Large divergent flow that destroys contrast and produces a homogenous air mass.
- Equilibrium between ground and air. This is achieved three ways.
  - Turbulent-convective transport of heat into the upper levels.
  - Cooling of air by radiation loss of heat.
  - Transport of air by evaporation and condensation.

Air Mass Types

- ARTIC (A)
  - Originates from the permanent High pressure area near the North Pole. A gentle flow of air over the ice fields allows this air mass to form. Usually dry aloft and cold and stable in lower altitudes.
- ANTARCTIC (A)
  - Source of extremely cold air masses. Before the air can reach other land areas it becomes modified and is called Maritime Polar air.

Air Mass Types

- CONTINENTAL POLAR (cP)
  - Originate over land dominated by Canadian and Siberian High Pressure cells. Because of the absence of water bodies, these air masses are very dry.
- MARITIME POLAR (mP)
  - Source regions are open unfrozen polar areas near 60 deg latitude, North and South. These air masses are cold and moist, but the moisture content is sharply limited by the cold temperatures.

Air Mass Types

- CONTINENTAL TROPICAL (cT):
  - Form over hot dry land areas between 25° north and south like the Sahara and Arabian deserts or the interior of Australia. Like the land areas they form over, the air is very hot and dry.
- MARITIME TROPICAL (mT):
  - Originates over the large subtropical anticyclone belt. High Pressure cells stagnate here most of the year. The air is warm because of the low latitude and can hold a high amount of moisture.

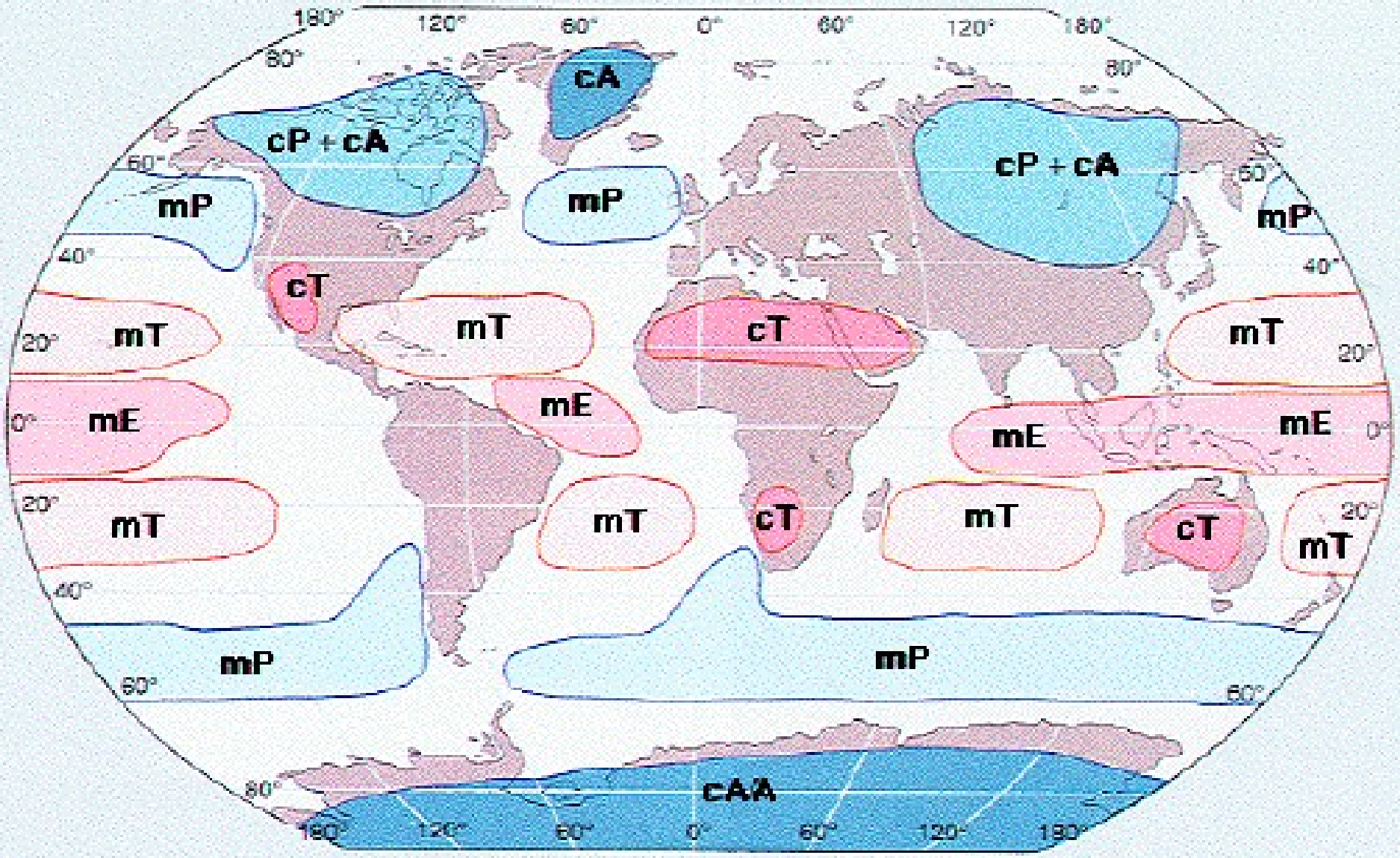
Air Mass Types

- EQUATORIAL (E)
  - The source region is between 10° north and south. It is simply an ocean belt that is extremely warm and moist. The air mass is very unstable and thunderstorms are abundant throughout the year.
- SUPERIOR (S)
  - This is a high level air mass found over the south central United States. Occasionally it reaches the surface; because of subsidence, it is the warmest air mass over the North American continent in both seasons.

Air Mass Types
Thermodynamic Classification

- COLD (k)
  - Air mass is colder than the underlying surface.
- WARM (w)
  - Air mass is warmer than the underlying surface.

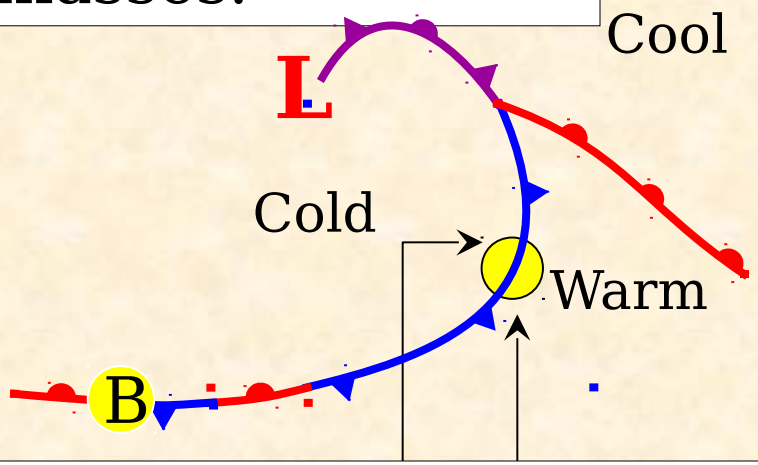
IR MASS SOURCE REGION

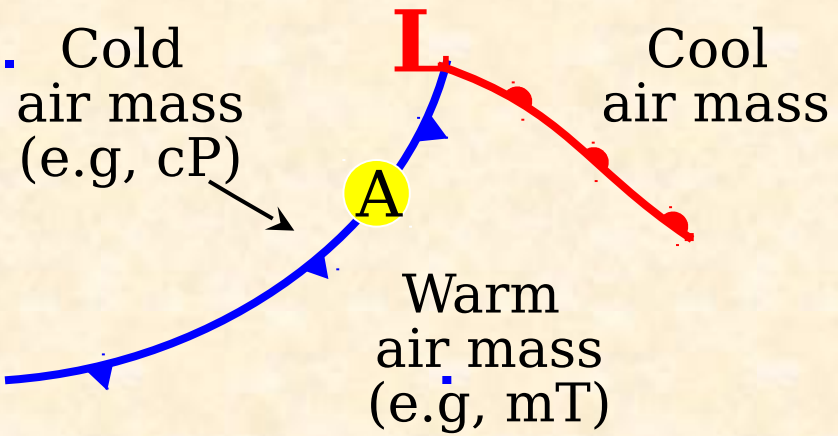


Fronts

A "front" is defined as the boundary, or transition zone, between two air masses.

Air mass characteristics on either side of a frontal boundary can be very different (point "A") or more similar (point "B").





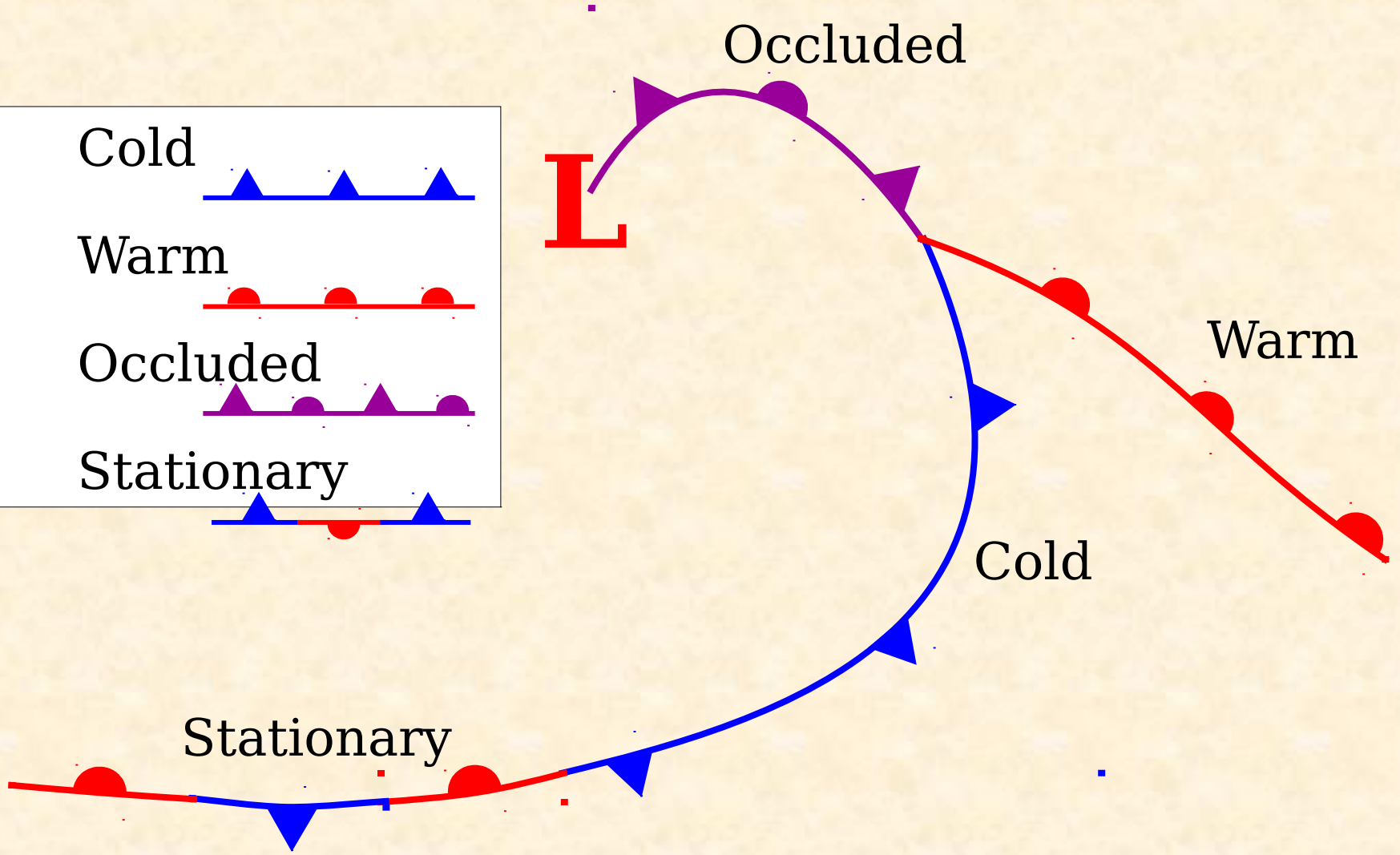
Frontal intensity is defined by the the temperature and moisture differences on either side.

The stronger the differences on either side of the front, the more potential for severe

Fronts

There are four types of fronts.

- Cold
- Warm
- Occluded
- Stationary

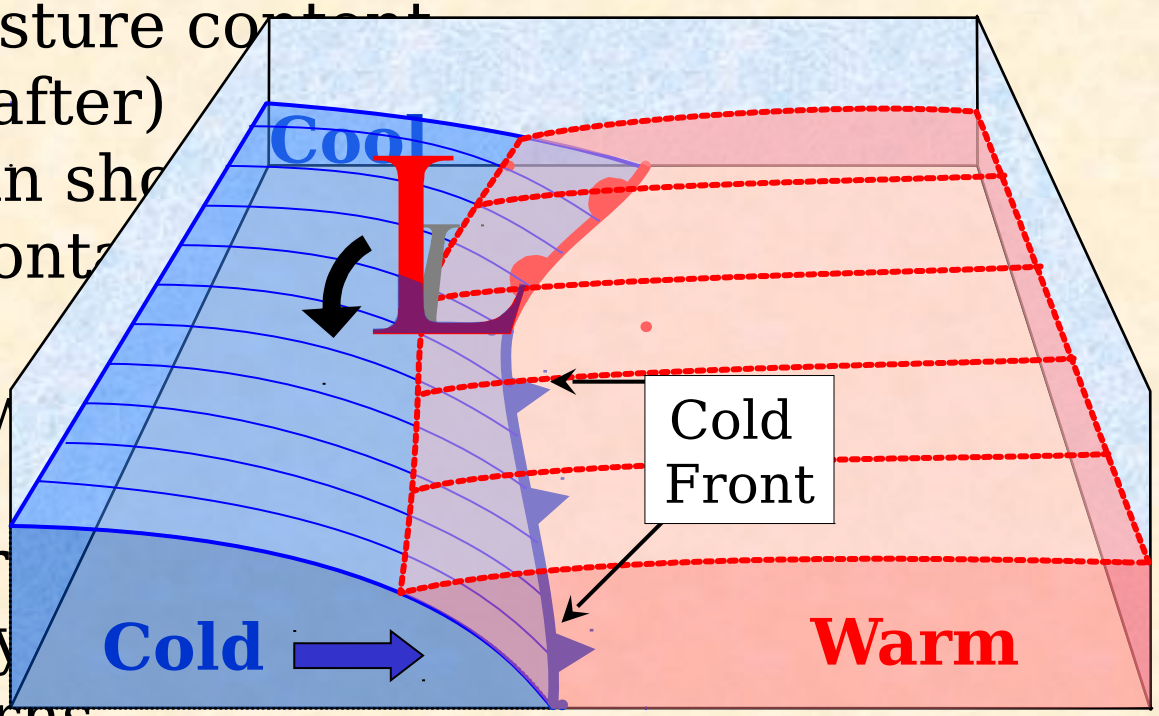


Cold Front

A cold front defines the boundary between an advancing cold air mass and a warm air mass.

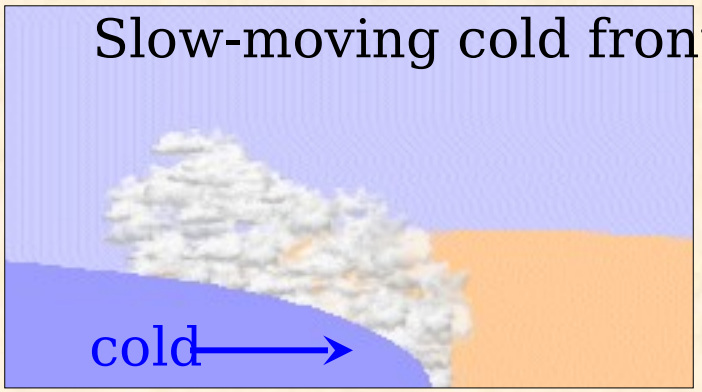
Cold fronts are associated with:

- Sharp temperature changes over relatively short distances
- Changes in air moisture co
  (moist before, dry after)
- Reduced visibility in sh
- Wind shifts with front
  passage
- Pressure changes w
  frontal passage
- Unstable cumulifor
  clouds and showery
  precipitation patterns



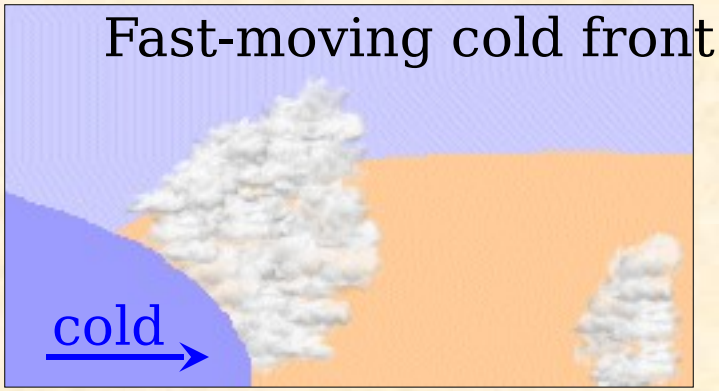
Cold Front

Cold fronts are further characterized by their speed of movement - which defines their slopes.



Slow moving cold fronts:

- Most clouds and weather are ***at and behind*** the advancing cold front
- Longer periods of rain/snow, less



Fast moving cold fronts (steeper slo

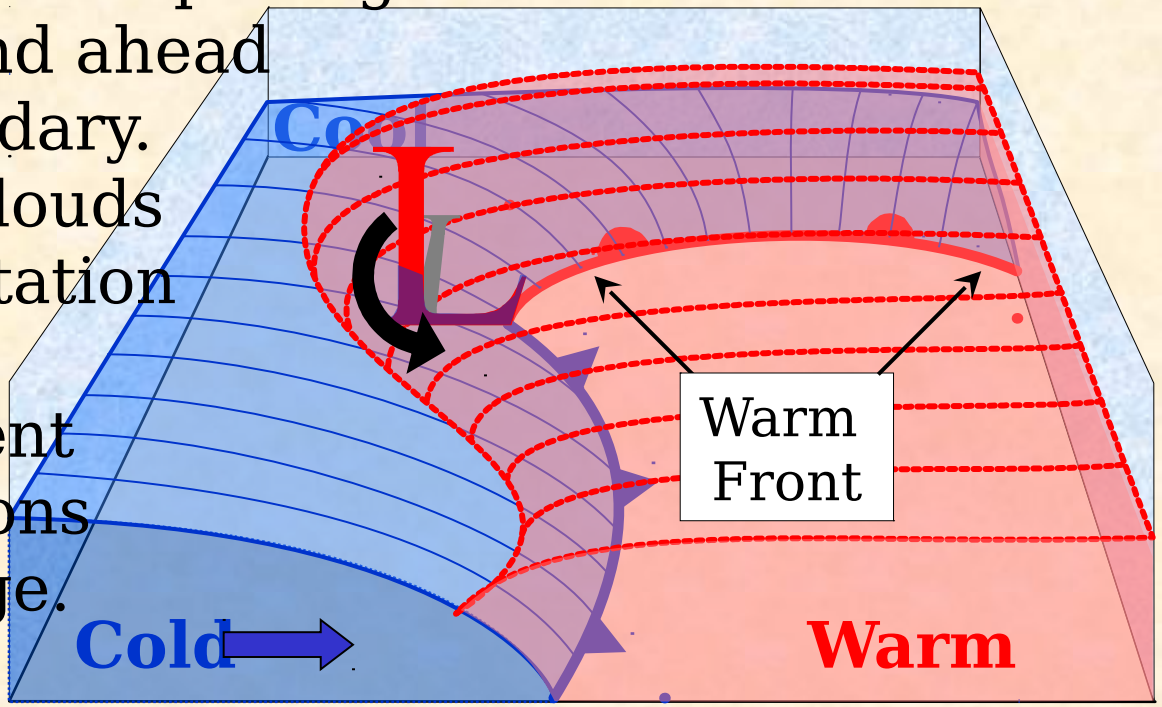
- Most clouds and weather are ***ahead*** of the advancing cold front
- Rain/show showers (sometim more thunderstorm activity
- Thunderstorms often form ah

Warm Front

A warm front defines the boundary between a retreating cool air mass and an overriding warm air mass.

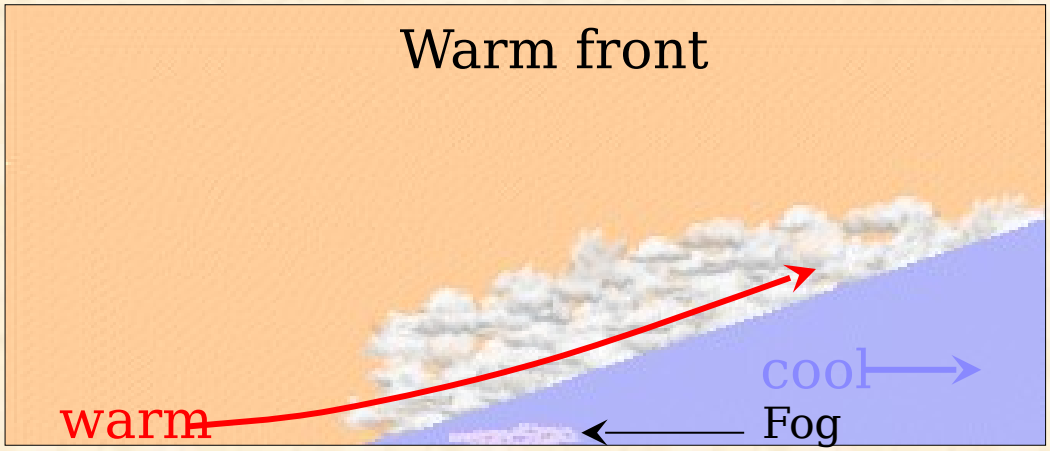
Warm fronts are associated with:

- Extensive cloud activity ahead of the front.
- Temperature rises with frontal passage.
- Wind shifts with frontal passage.
- Poor visibility at and ahead of the frontal boundary.
- Thick, stratiform clouds and steady precipitation patterns.
- Overall improvement in weather conditions with frontal passage.



Warm Front

Warm fronts have extremely shallow slopes.



- Clouds and weather are ***at and ahead*** the advancing warm front.
- Precipitation consists of steady rain or snow and ***usually*** no thunderstorm activity - although thunderstorms may be embedded within the frontal area and hard to discern on satellite pictures.

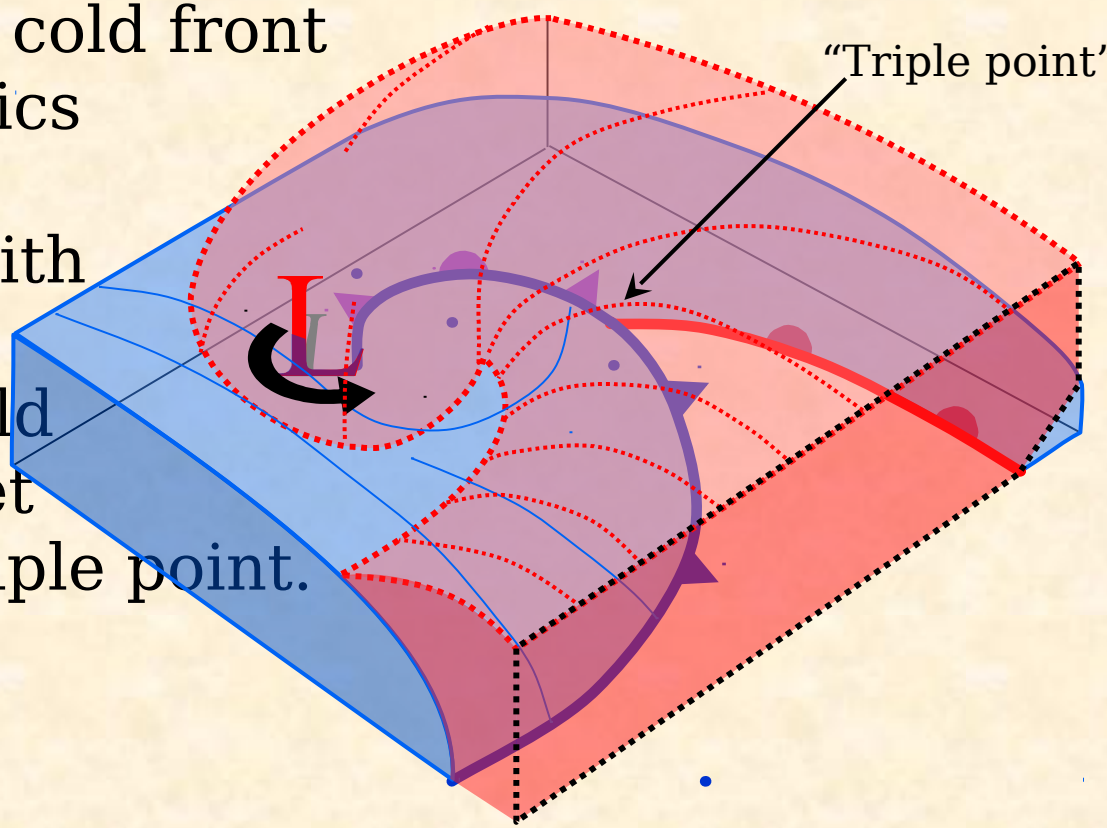
Occluded Front

An occluded front defines the portion of frontal area where the cold front has overtaken the warm front and pushed it aloft.

Occluded fronts are associated with:

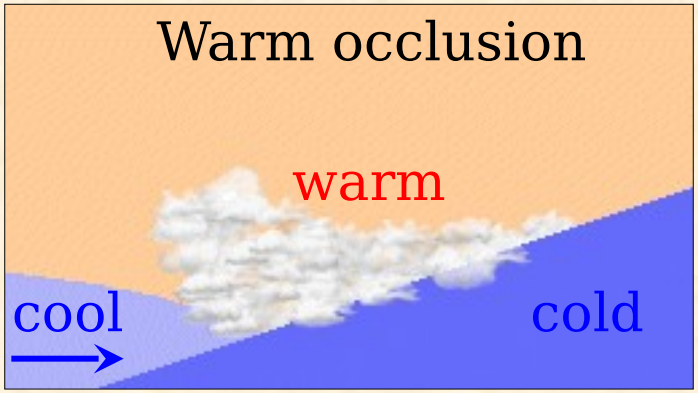
- Both warm front and cold front weather characteristics

- The worst weather with an occluded front is located where the cold and warm fronts meet at the surface: the triple point.



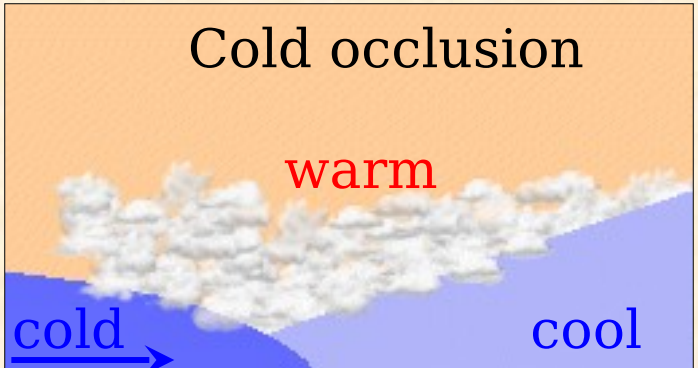
Occluded Front

There are two types of occluded fronts: warm, and cold.



Warm occlusions:

- Milder maritime polar (mP) air overtakes colder continental polar (cP) air.
- Warm occlusion weather is similar to that of a warm front.
- More steady, less showery



Cold occlusions:

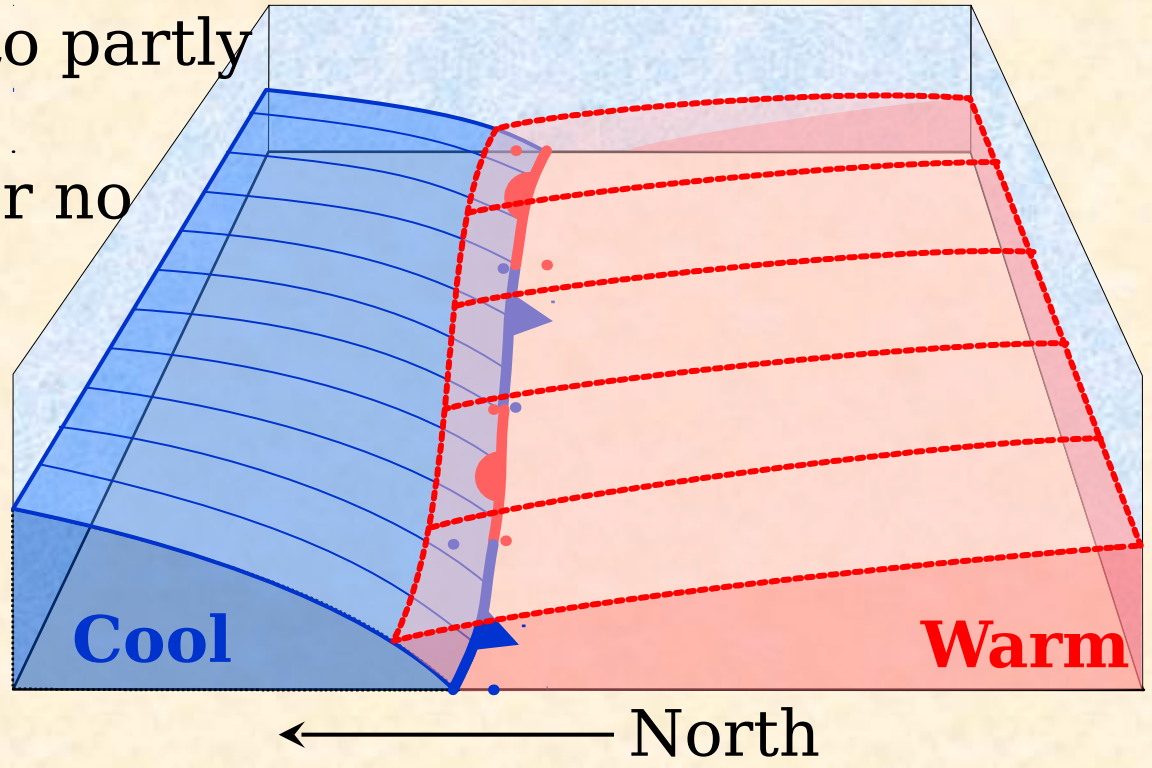
- Colder cP air overtaking mild
- Cold occlusion weather resem
  frontal weather before the front p
  and cold frontal weather during a
  passage.

Stationary Front

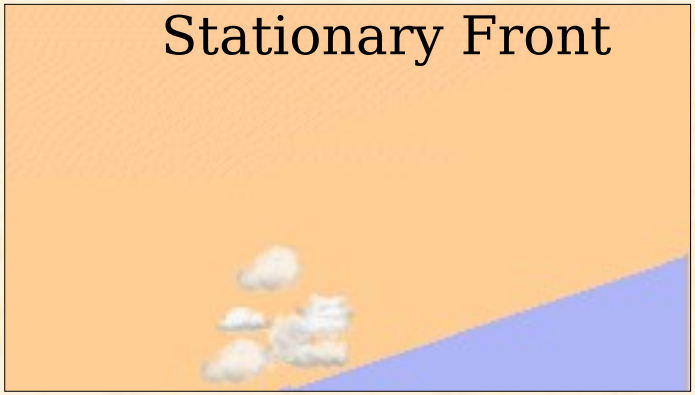
A stationary front has essentially no movement.

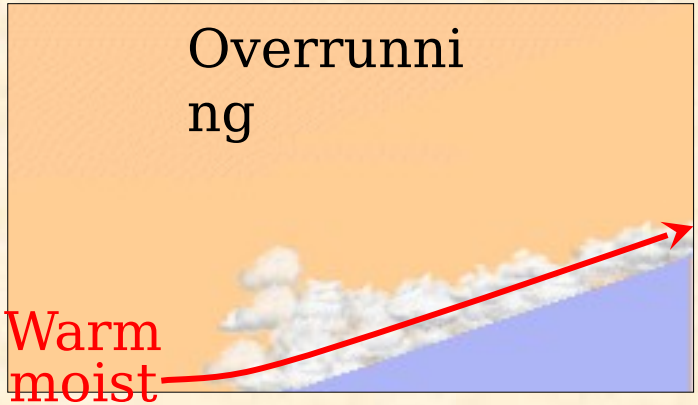
Stationary fronts are associated with:

- East-west orientation.
- ***Normally*** clear to partly cloudy skies.
- ***Normally*** little or no precipitation.



Stationary Front





Stationary fronts:

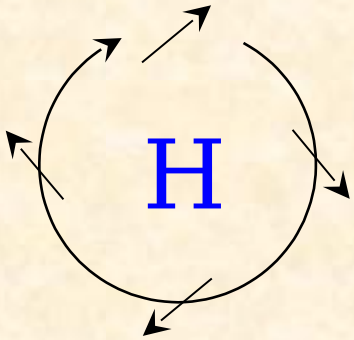
- Normally have “good” weather associated with them.

Exceptions:

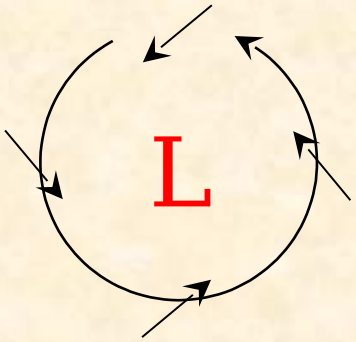
- If a new pulse of cold air moves in from the north, the cold front can begin to advance and a new low can form on the frontal boundary.
- If warm, moist air overruns the frontal boundary, widespread cloudiness and light precipitation can cover a vast

Pressure Systems

There are two types of pressure systems: Highs and



A “high,”or anticyclone, is an area of high pressure around which the winds blow clockwise in the northern hemisphere (counterclockwise in the southern hemisphere.) High pressure is associated with sinking, more dense air.



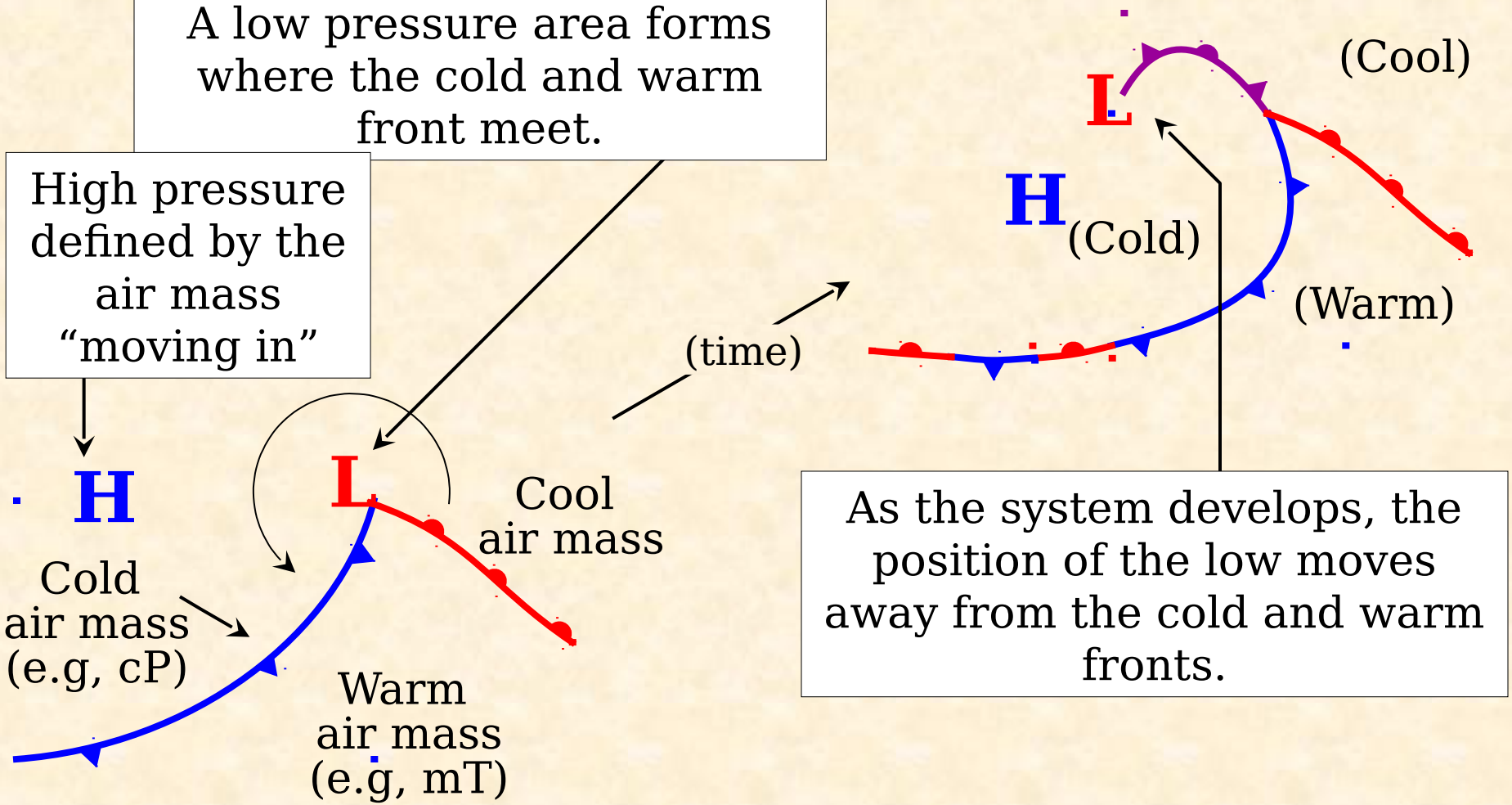
A “low,”or cyclone, is an area of low pressure around which the winds blow counterclockwise in the northern hemisphere (clockwise in the southern hemisphere.) Low pressure is associated with rising, less dense air.

Pressure Systems and Fronts

Pressure systems and fronts have a direct relations

A low pressure area forms where the cold and warm front meet.

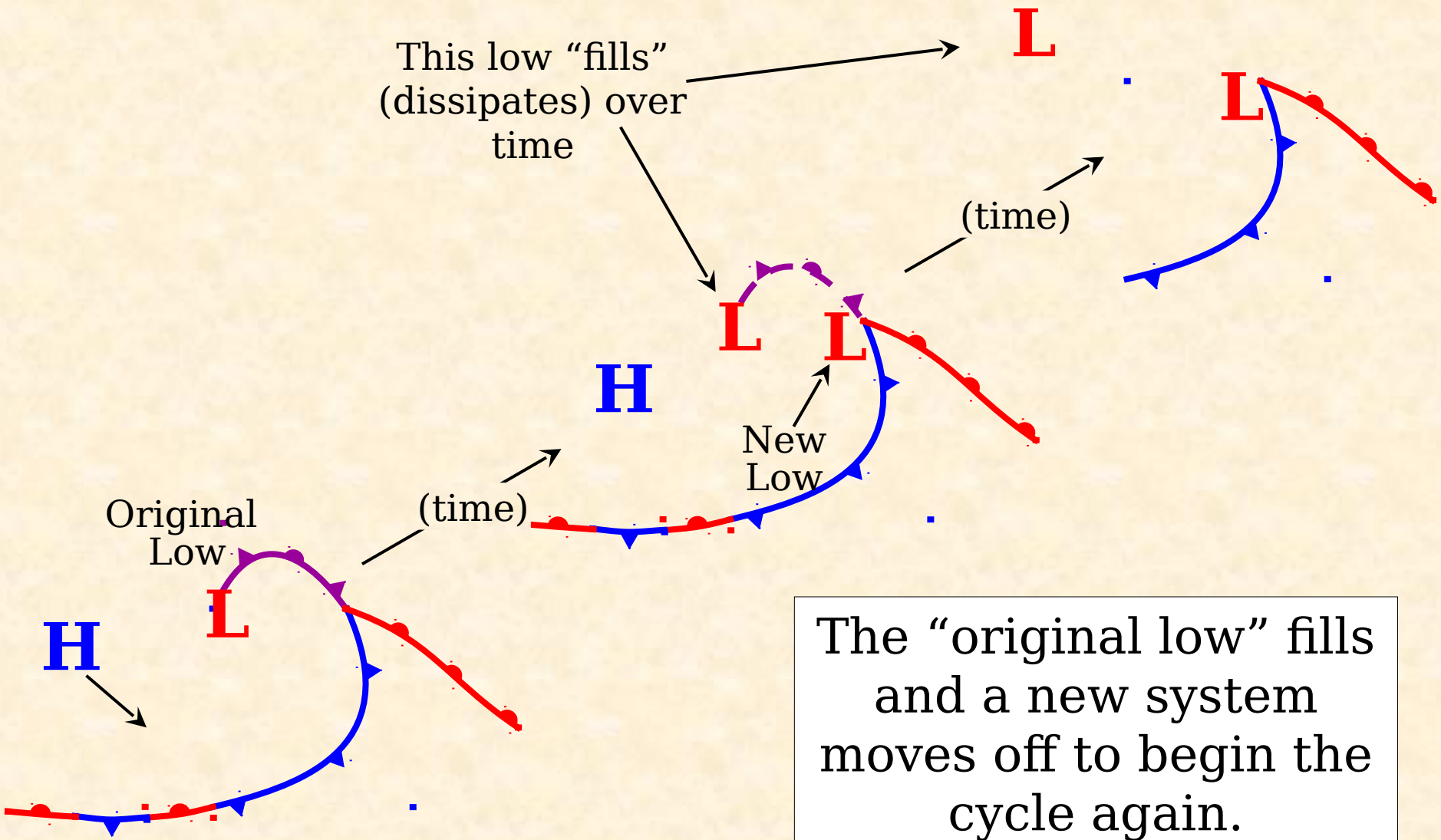
High pressure defined by the air mass "moving in"



As the system develops, the position of the low moves away from the cold and warm fronts.

Pressure Systems

New Lows frequently form at the "triple point."



The "original low" fills and a new system moves off to begin the cycle again.

CLOUDS

Clouds are:

- Water molecules suspended in the atmosphere.

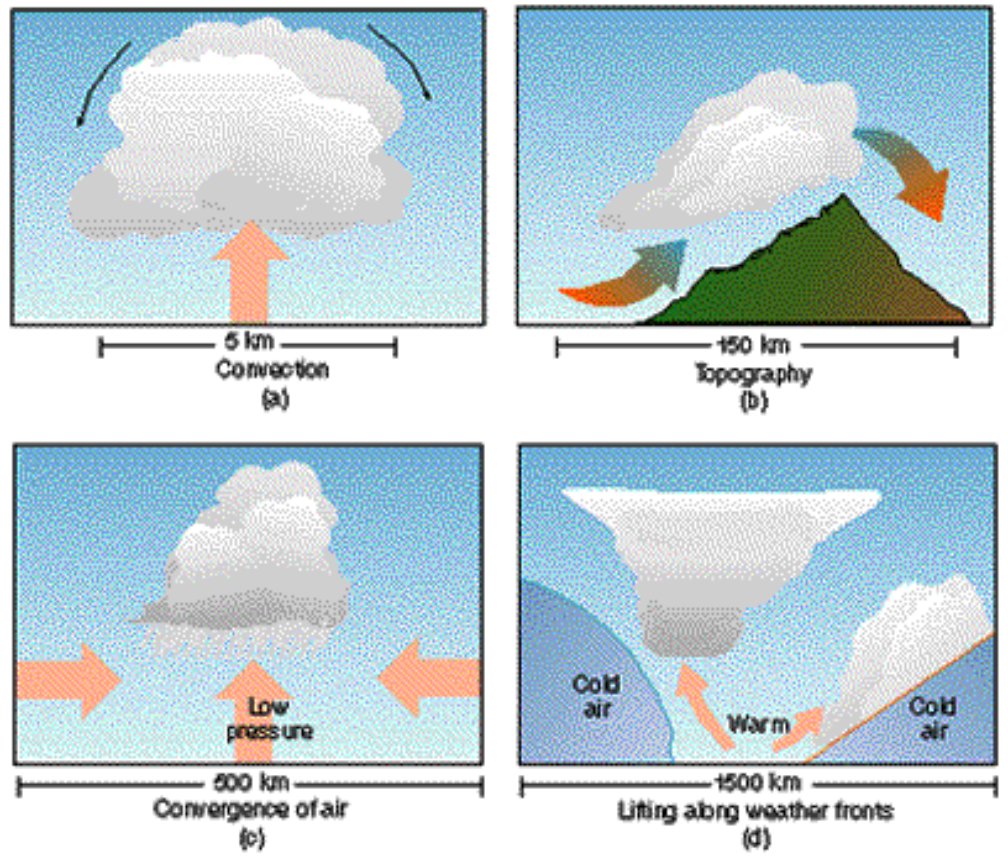
- Three things are required for cloud formation:
  - Water Vapor / Moisture
  - Cooling mechanism
  - Condensation nuclei (something for the moisture to condense on)

There are three general types of clouds:

- Cumuliform
- Stratiform
- Cirriform

CLOUD FORMATION

- **Convective Lifting or Convection - ascending air caused by strong heating at the Earth's surface.**
- **Orographic Lifting - air that is forced upward by mountainous terrain.**
- **Convergence - air that is forced upward by convergence of air near the ground. A shear line, depicted on a weather map as an alternating dotted and dashed line, identifies a line of convergence at the surface.**
- **Frontal lift - a process by which air is forced upward by the displacement of one airmass by a different airmass. This process occurs near cold fronts, where cold air displaces warm air and forces the warm air upward. Near warm fronts**



Cumuliform Clouds

Cumuliform clouds are unstable, vertically developed, and have generally distinct edges. They are formed either by convective action (daytime heating) or mechanical lifting (cold front). Showery precipitation is associated with cumuliform clouds. Cumulonimbus clouds are clouds with extreme vertical extent and are associated with heavy precipitation and thunderstorms.

Stratiform clouds are stable and form indistinct layers. Steady, light precipitation is associated with stratiform clouds. A particular form of stratiform clouds, nimbostratus, is associated with heavy, steady precipitation. Fog is nothing more than a form of stratiform clouds (stratus) that has reached the ground.

Clouds and the Atmosphere

For meteorological purposes, the atmosphere is divided into three levels ("etages").

- Low etage - Surface to 6500 ft (middle latitudes)
- Middle etage - 6500 ft to 23,000 ft
- High etage - 16,00 ft to 43,000 ft

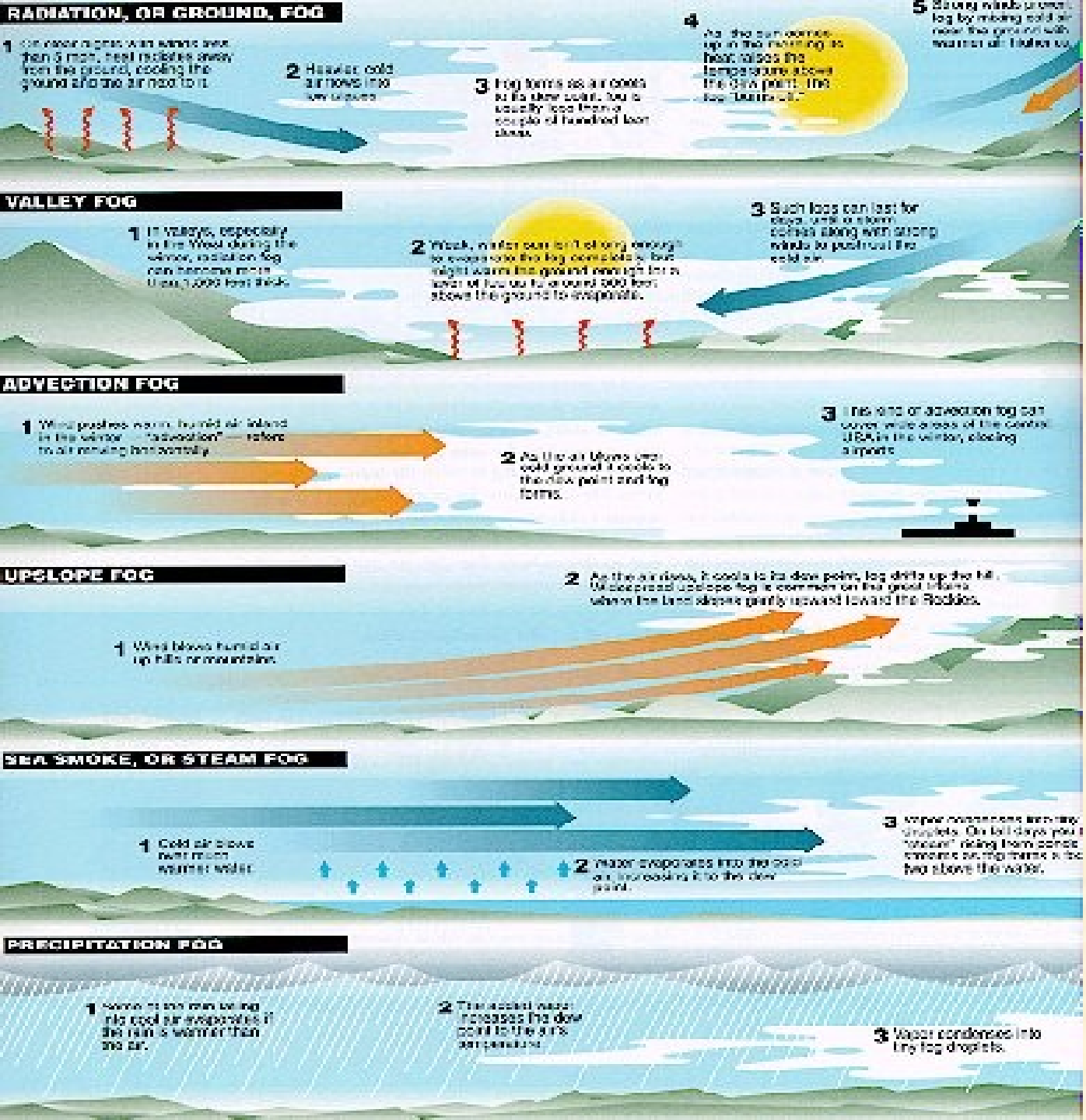
Different cloud types are associated with the low, middle, and high etages. More common cloud types are shown below. Some "stay" in their etages, some extend through one or more (*):

Low	Middle	High
Cumulus, Cumulonimbus *		Altostratus
Cirrus		


FOG

WHAT IS FOG?

- SURFACE BASED STRATUS CLOUD.
- FORMS WHEN CONDITIONS ARE STABLE
- GENERALLY LIGHT WINDS
- HIGH RELATIVE HUMIDITY
- CONDITIONS WHICH BRING THE AIR TO IT'S DEWPOINT.



Types of Fog

Radiation/Grou

Valley

Advection

Upslope

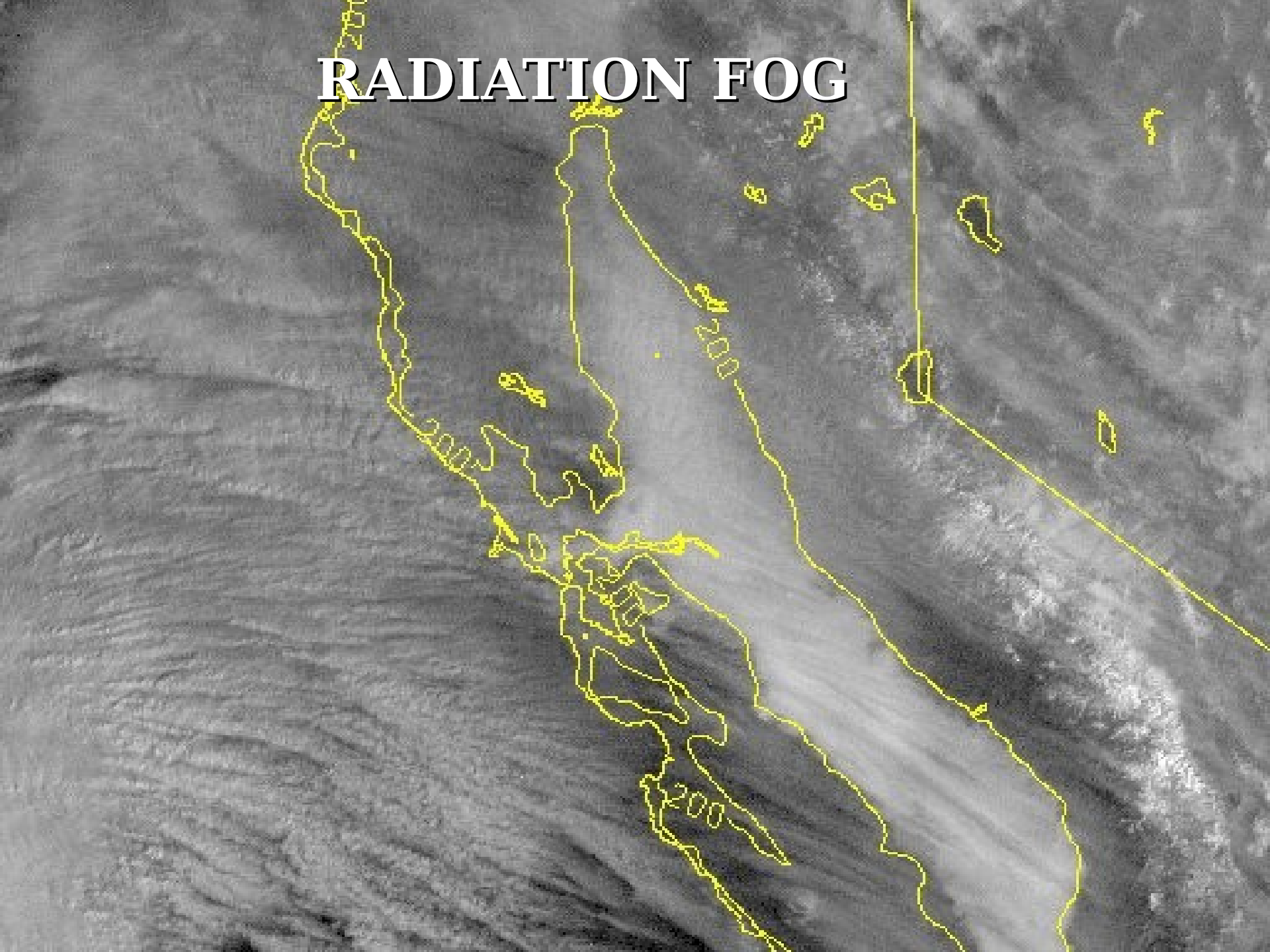
Steam/Sea Smo

Precipitation

RADIATION FOG

- Commonly referred to as ground or valley fog.
- Caused by radiant cooling of the Earth surface - nocturnal cooling of air temperature to dew point.
- Common on clear nights with shallow moist layer capped by dry layer aloft - areas of HIGH PRESSURE.

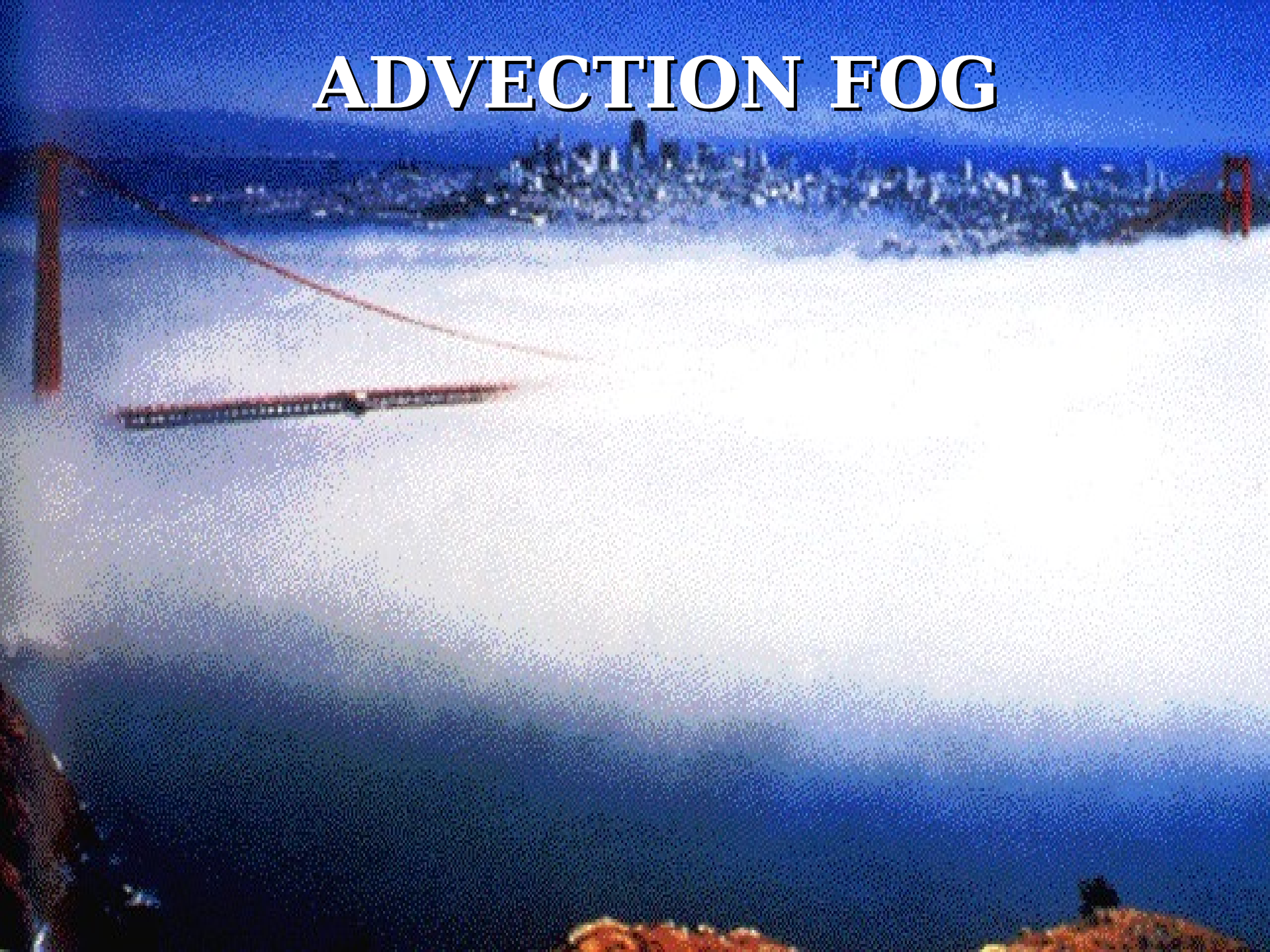
RADIATION FOG



ADVECTION FOG

- HORIZONTAL TRANSPORT OF (TYPICALLY) WARM MOIST AIR OVER A COOLER SURFACE
- THE TEMPERATURE CONTRAST CAUSES THE TRANSFER OF HEAT FROM AIR TO SURFACE WHICH COOLS THE AIR TO ITS DEW POINT AND PRODUCES FOG.

ADVECTION FOG



ADVECTION FOG TYPES

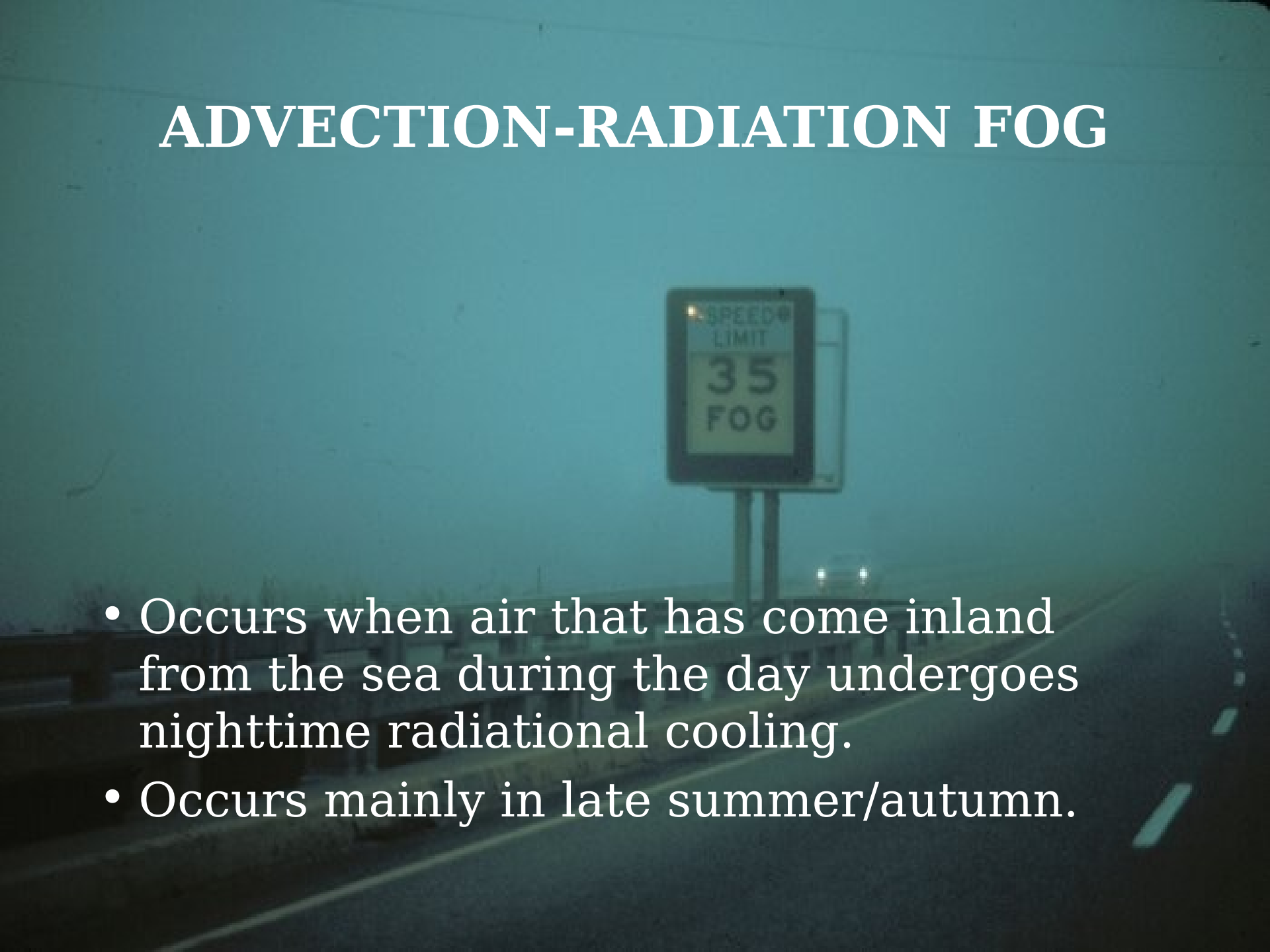
LAND ADVECTION FOG

1. FOUND NEAR LARGE BODIES OF WATER.
2. CANNOT EXIST IN HIGH WIND SPEEDS
3. FORMS WHEN ONSHORE BREEZES MOVE MARITIME AIR OVER A RADIATIONALLY COOLED LAND SURFACE.

ADVECTION FOG TYPES: SEA FOG

- CAN EXIST WITH STRONGER WINDS
- OCCURS WHEN WARM MOIST AIR MOVES OVER COLDER WATER.
- GREATER TEMPERATURE DIFFERENCE= DEEPER,. DENSER FOG

ADVECTION-RADIATION FOG



- Occurs when air that has come inland from the sea during the day undergoes nighttime radiational cooling.
- Occurs mainly in late summer/autumn.

UPSLOPE FOG

- FOG THAT FORMS AS MOIST AIR FLOWS UP AN ELEVATED PLAIN, HILL, OR MOUNTAIN.
- CAUSED BY ADIABATIC COOLING OF RISING AIR DUE TO GRADUAL OROGRAPHIC LIFT.
- MAY OCCUR IN RELATIELY HIGH WIND SPEEDS, HOWEVER WINDS GREATER THAN 12 KNOTS WILL USUALLY PRODUCE STRATUS.

STEAM FOG

- OCCURS WHEN COLD AIR MOVES OVER WARM WATER.
- FORMS ON CLEAR NIGHTS INLAND OVER LAKES AND RIVERS.
- CAUSED BY RAPID EVAPORATION OF MOISTURE INTO RELATIVELY COLD AIR - USUALLY 2-3 FT. THICK

FRONTAL FOG

- CAN FORM IN ADVANCE OF A WARM FRONT (OR BEHIND A WARM FRONT IF THE WARM AIR DEW POINT IS HIGHER THAN THE COLD AIR TEMPERATURE.)

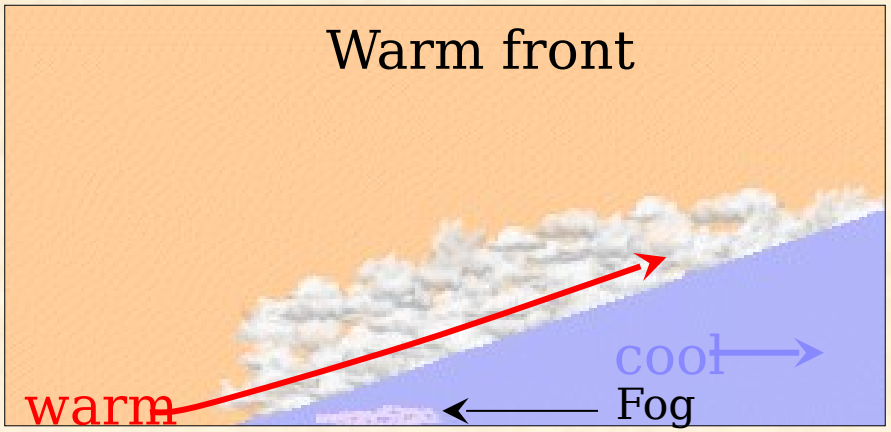
- CAN FORM BEHIND A SLOW MOVING COLD FRONT WHEN THE AIR BECOMES SATURATED

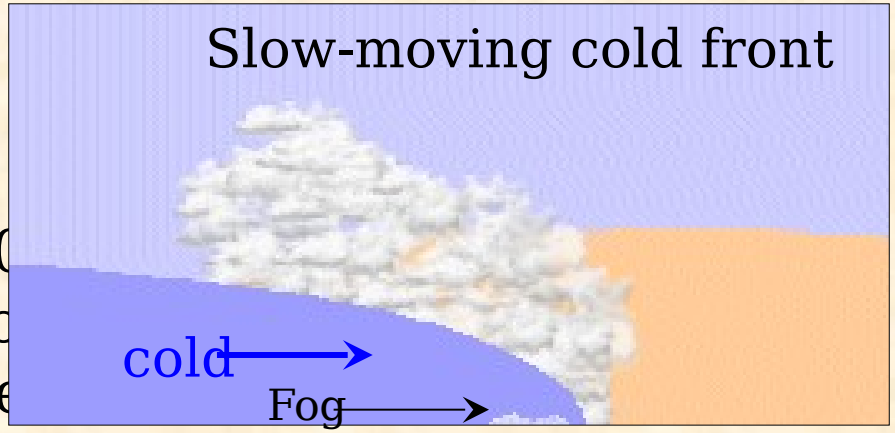
Frontal Fog

- Warm fronts: fog is more widespread than with cold fronts; caused by warm rain falling into colder air
- Cold fronts:

  - Fog occurs with both active (slow moving) and inactive (fast moving) cold fronts

  - Usually found up to 150 - 20 miles behind the surface fro due to the saturated surface





AIRCRAFT ICING

TYPES OF ICING:

- CLEAR - Glossy, clear or translucent ice formed by relatively slow freezing of large supercooled water droplets
- RIME - Formed by the instantaneous freezing of small supercooled droplets. As drops strike aircraft and freezing takes place, air is trapped and produces a rough, milky - opaque appearance
- MIXED - Combination of clear and rime ice

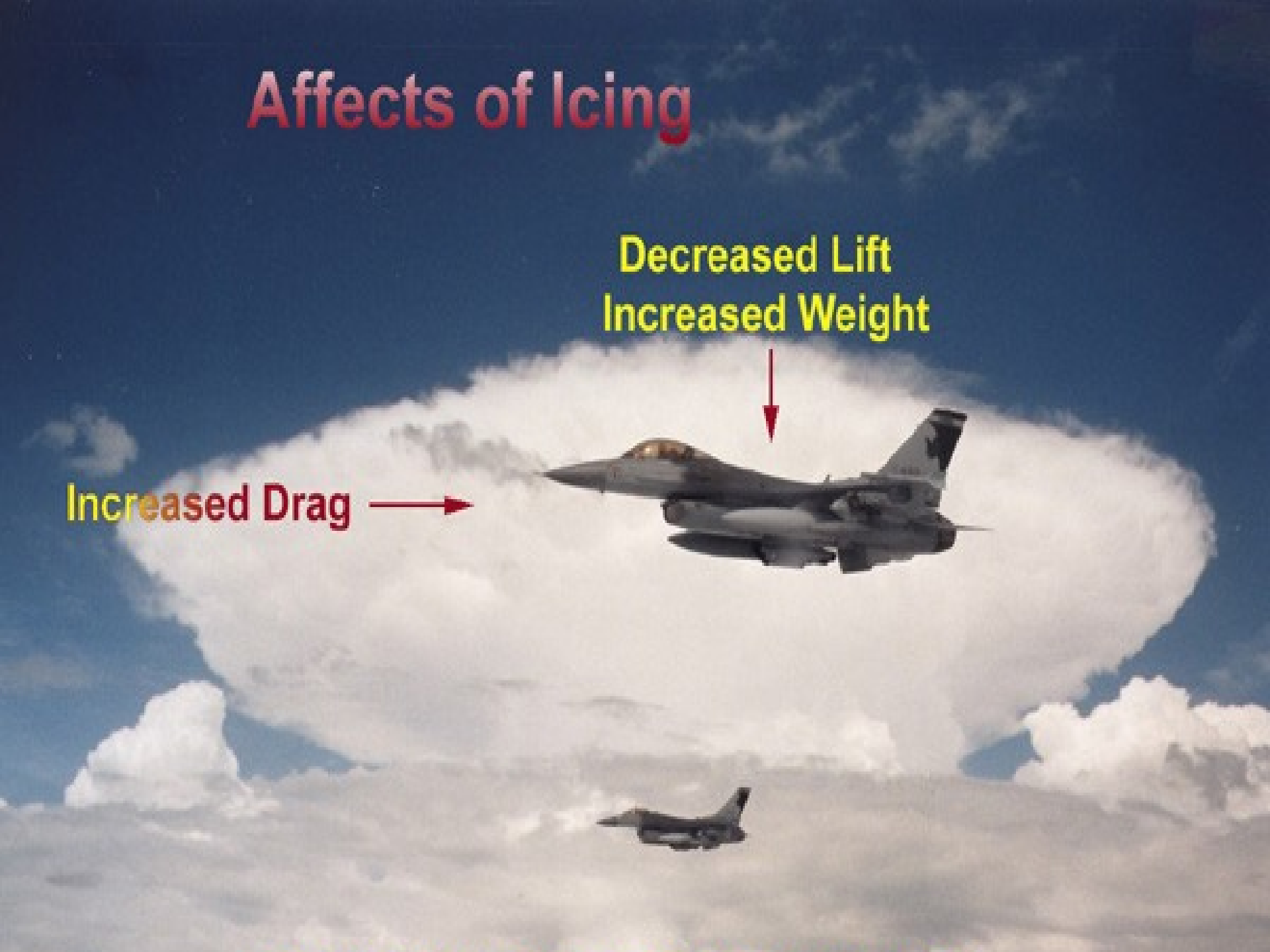
RATE OF ACCUMULATION: CONTRIBUTING FACTORS

- Amount of liquid water
- Droplet size
- Airspeed
- Aircraft size and shape

ICING INTENSITIES

- **Trace** - Ice becomes perceptible. Not hazardous unless encountered for more than an hour
- **Light** - Rate of accumulation may create a problem if flight is over 1 hour in this environment. Occasional use of de-icing equipment removes/prevents accumulation.
- **Moderate** - Rate of accumulation is such that even short encounters become potentially hazardous - use of de-icing equipment or diversion is necessary.
- **Severe** - Rate of accumulation is such that de-icing equipment fails to reduce or control the hazard - immediate diversion is required.

Affects of Icing



ICING CONSIDERATIONS

- Generally occurs between the freezing level and -22 C -- can occur at temps as cold as -42 C in upper parts of cumulonimbus.
- Stratiform Clouds - usually produce rime ice at elevations where temps are -1 to -15 C. Typically extensive areas in the horizontal.
- Cumuliform Clouds - Icing zone smaller horizontally, but greater vertically. In general - produce clear ice where temps vary from 0 to -8 C, mixed from -9 to -15 C, and rime from -15 to -22 C.

TURBULENCE

TYPES OF TURBULENCE

- THERMAL - Associated with surface heating / convection

- MECHANICAL - Caused by horizontal and vertical wind shear as result of pressure gradient differences, terrain obstructions, or frontal zones

MECHANICAL TURBULENCE
FURTHER BROKEN DOWN INTO:

- **CLEAR AIR TURBULENCE (CAT)**
- Includes all turbulence not associated with visible convective activity, high-level frontal and jet stream turb, may occur in high level, non-convective clouds
- **MOUNTAIN WAVE (MW)**
- Often occurs in clear air downwind of a prominent mountain range
- **WAKE TURBULENCE**
- Although neither forecasted nor recorded, it is a problem with the increased use of heavy aircraft; occurs when an aircraft encounters the vorticies produced by another aircraft.

TURBULENCE CLASSIFICATIONS

- LIGHT - Aircraft experiences slight erratic change in attitude and/or altitude. Usually produces a slight variation in airspeed of 5-14 knots with vertical gust velocity of 5-19 feet per second
- May be found in areas such as:
- 1) mountainous areas, even with light wind
- 2) in/near cumulous clouds
- 3) near the tropopause
- 4) at low altitudes in rough terrain where winds exceed 15 knots

TURBULENCE CLASSIFICATIONS

- MODERATE - Aircraft experiences moderate changes in attitude/altitude, but remains in positive control at all times. Usually small variations in airspeed of 15-24 knots, vertical gust velocity 20-35 feet per second
- May be found:
- 1) in mountain waves as far as 300 mi. leeward a ridge when winds perpendicular to the ridge exceed 50 knots.
- 2) in TCUs, CBs
- 3) within 100 nm of the jet stream on the cold air side
- 4) at low altitudes in rough terrain when winds exceed 25 knots

TURBULENCE CLASSIFICATIONS

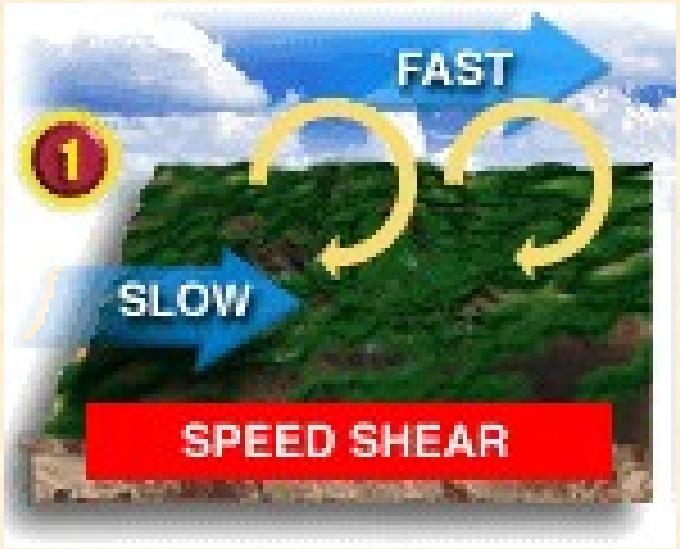
- SEVERE - aircraft experiences abrupt changes in attitude/altitude and may be out of control for short periods, usually large variations in airspeed (greater than 25 kt) and vertical gust velocity is 36-49 feet per second
- May occur:
- 1) up to 150 mi.. leeward of a ridge when a mountain wave exists and winds perpendicular to the ridge exceed 50 knots
- 2) in and near a mature thunderstorm
- 3) near jet stream altitude - 50-100 nm on cold air side of jet core

TURBULENCE CLASSIFICATIONS

- EXTREME - Aircraft violently tossed about and impossible to control. Structural damage may occur. Rapid fluctuations in airspeed are the same as severe turb. (more than 25 kt) and vertical gust velocity is greater than 50 fps
- Usually found in the strongest forms of convection and wind shear.
- Most frequent locations are:
- 1) in mountain waves in/near the rotor cloud
- 2) in severe thunderstorms

LOW LEVEL WIND SHEAR (LLWS)

Caused by change in wind speed and/or direction over a short distance or period of time, resulting in a shearing action



WITHIN 2,000 FEET OF GROUND

LLWS

- FAVORABLE CONDITIONS:

- 1) Thunderstorm outflow boundaries and/or downbursts
- 2) Strong frontal boundaries
- 3) Low-level jets

HORIZONTAL AND VERTICAL WIND SPEED SHEAR

Horizontal Wind Speed Shear, kn/90 nmi	Vertical Wind Speed Shear, kn/1,000 ft	CAT Intensity
<25	3 to 5	LIGHT
25 to 49	6 to 9	MODERATE
50 to 89	10 to 15	SEVERE
>90	>15	EXTREME

DIRECTIONAL WIND SHEAR

Mean Wind Speed in Layer, knots	Vector Wind Shear Difference in the Vertical, kn/1,000 ft					
	5-7	8-10	11-20	21-30	31-50	>50
40 to 60	N	L	L-M	M	M-S	S
61 to 120	L	L-M	M	M-S	S	S-X
>120	L	L-M	M	M-S	S	X

N = None L = Light M = Moderate S = Severe X = Extreme

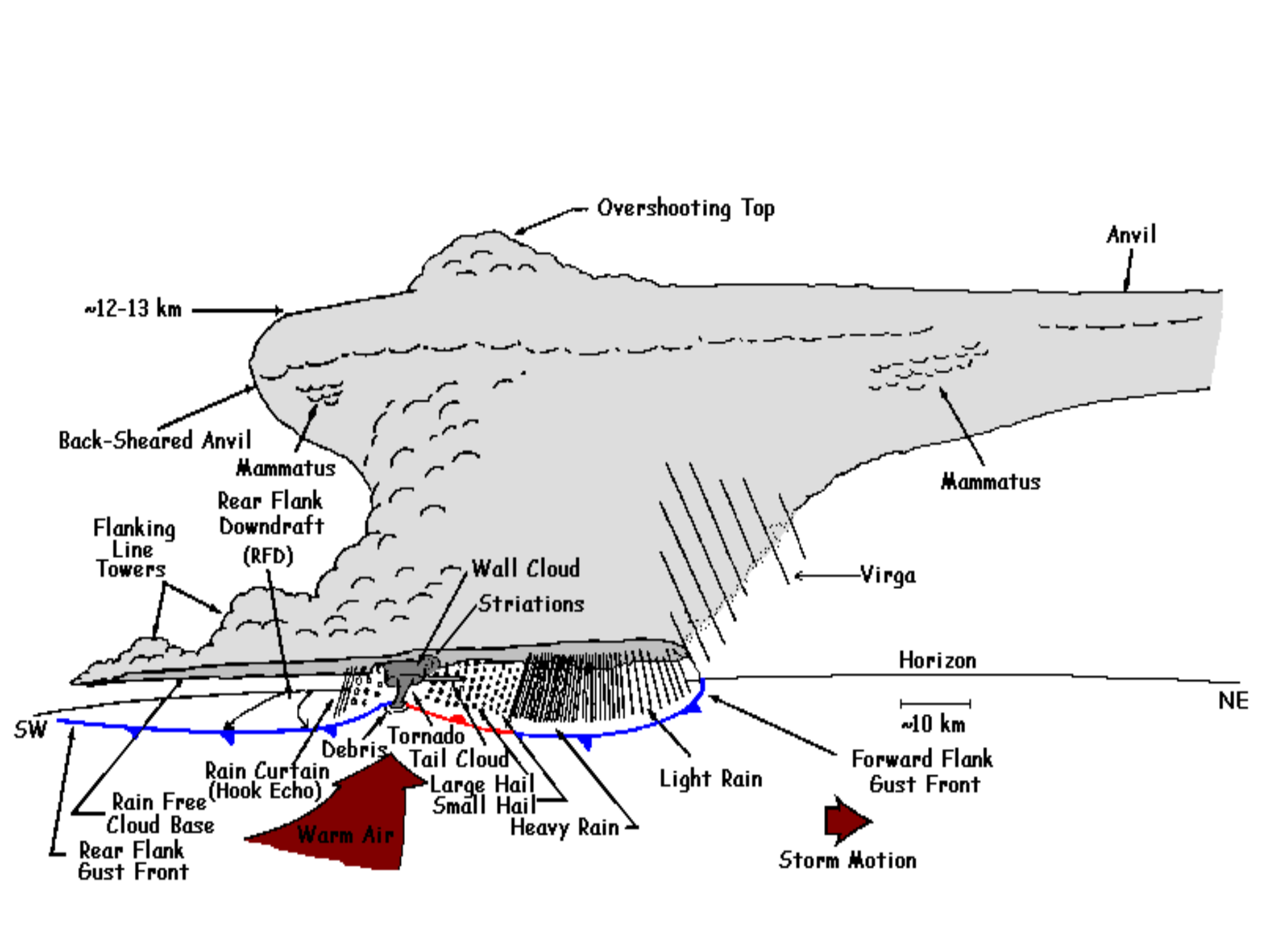
THUNDERSTORMS

INDIVIDUAL STORM TYPES

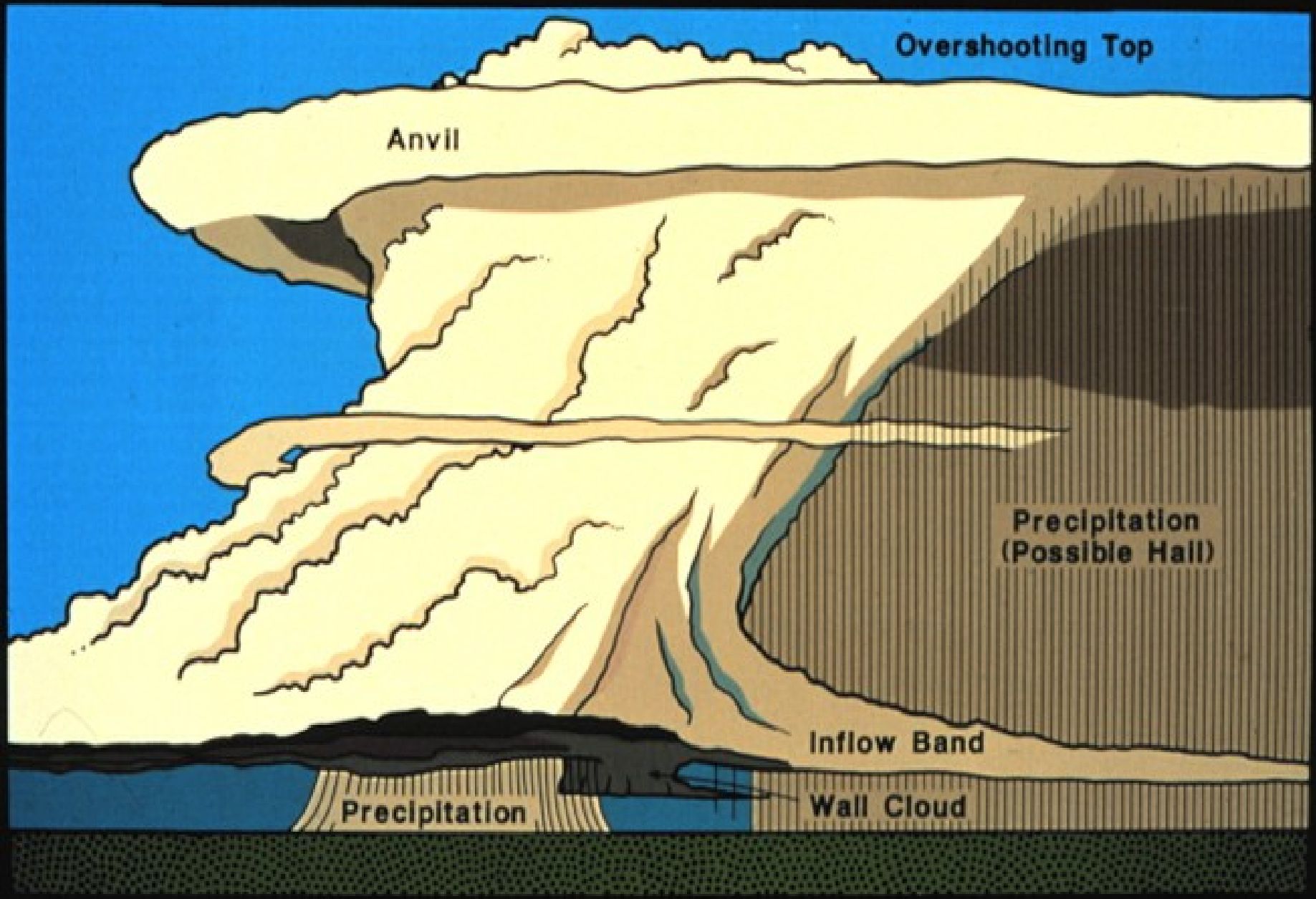
Single Cell

Multi Cell

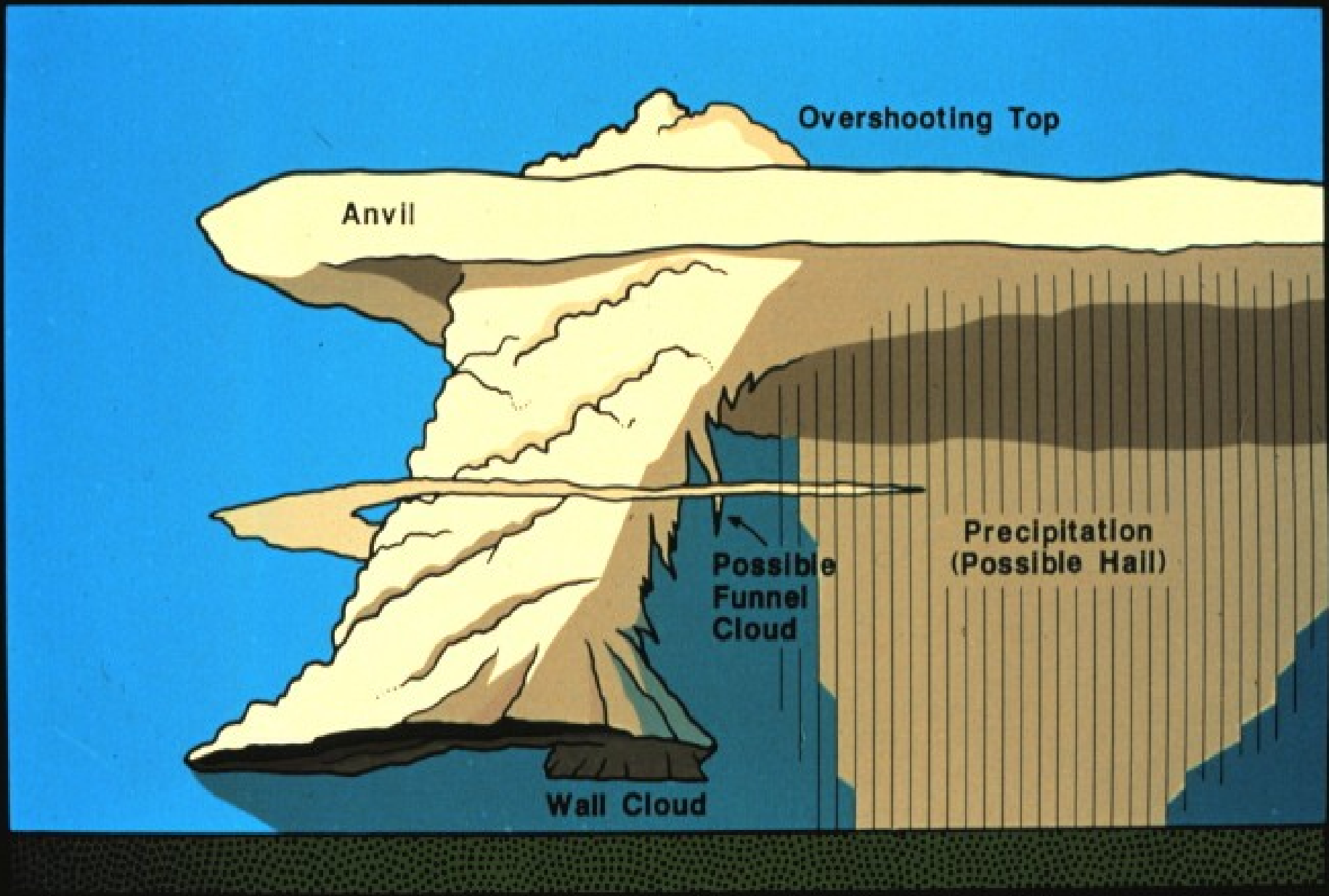
Super Cell
- Classic
- High Precip.
- Low Precip.


Overshooting Top
Anvil
~12-13 km
Back-Sheared Anvil
Mammatus
Rear Flank
Downdraft
(RFD)
Flanking
Line
Towers
Wall Cloud
Striations
Mammatus
Virga
Horizon
NE
SW
~10 km
Debris
Tornado
Tail Cloud
Rain Curtain
(Hook Echo)
Large Hail
Small Hail
Heavy Rain
Light Rain
Forward Flank
Gust Front
Rain Free
Cloud Base
Warm Air
Rear Flank
Gust Front
Storm Motion

HEAVY PRECIPITATION SUPERCELL (b)



LOW PRECIPITATION SUPERCELL (b)



MESOSCALE CONVECTIVE WEATHER SYSTEMS

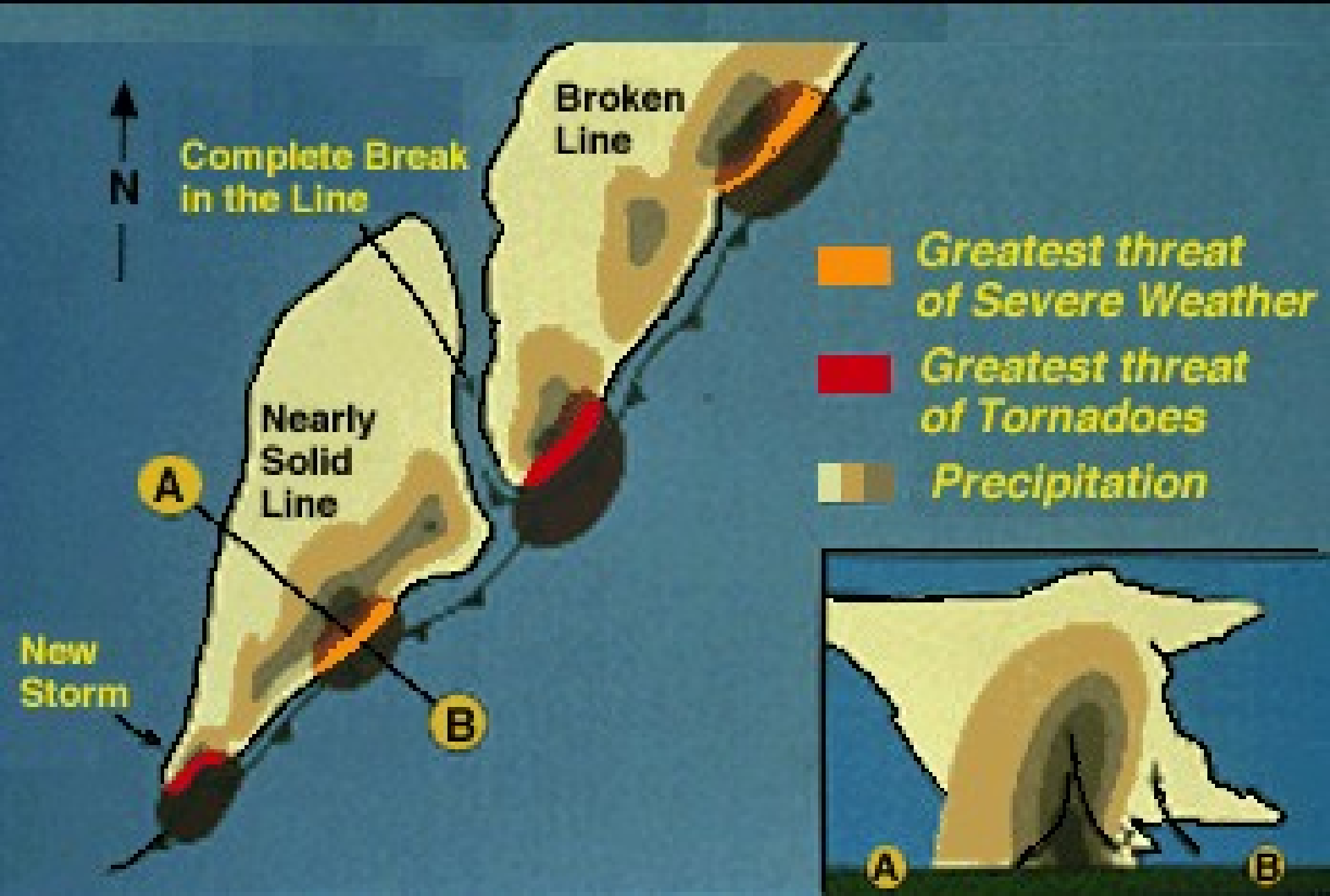
LINEAR TYPE

- **Squall line**
- **Tropical Squall**

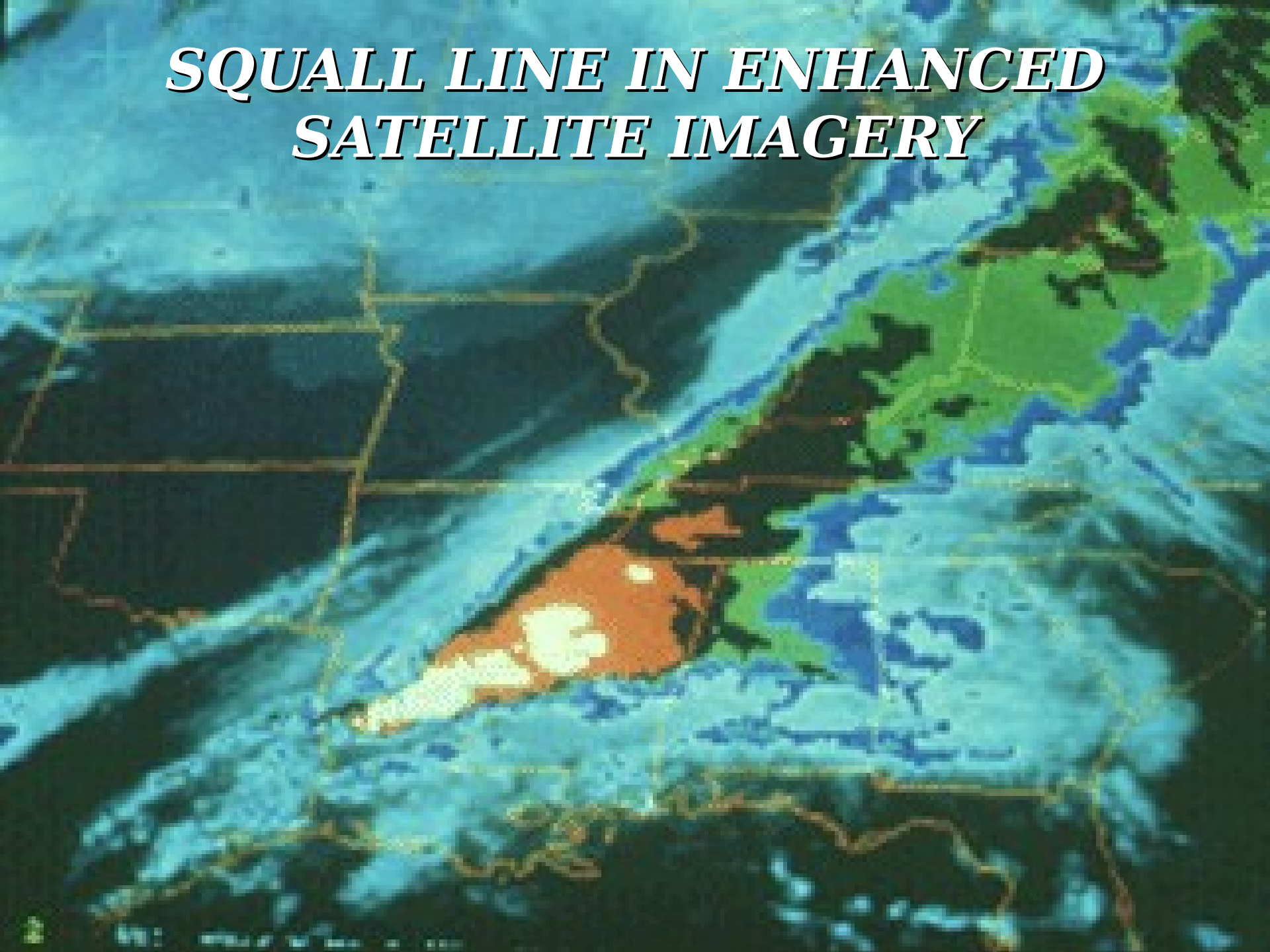
CIRCULAR TYPE

- **Cloud cluster**
- **Mesoscale Convective System / Complex (MCS/MCC)**
- **Tropical**

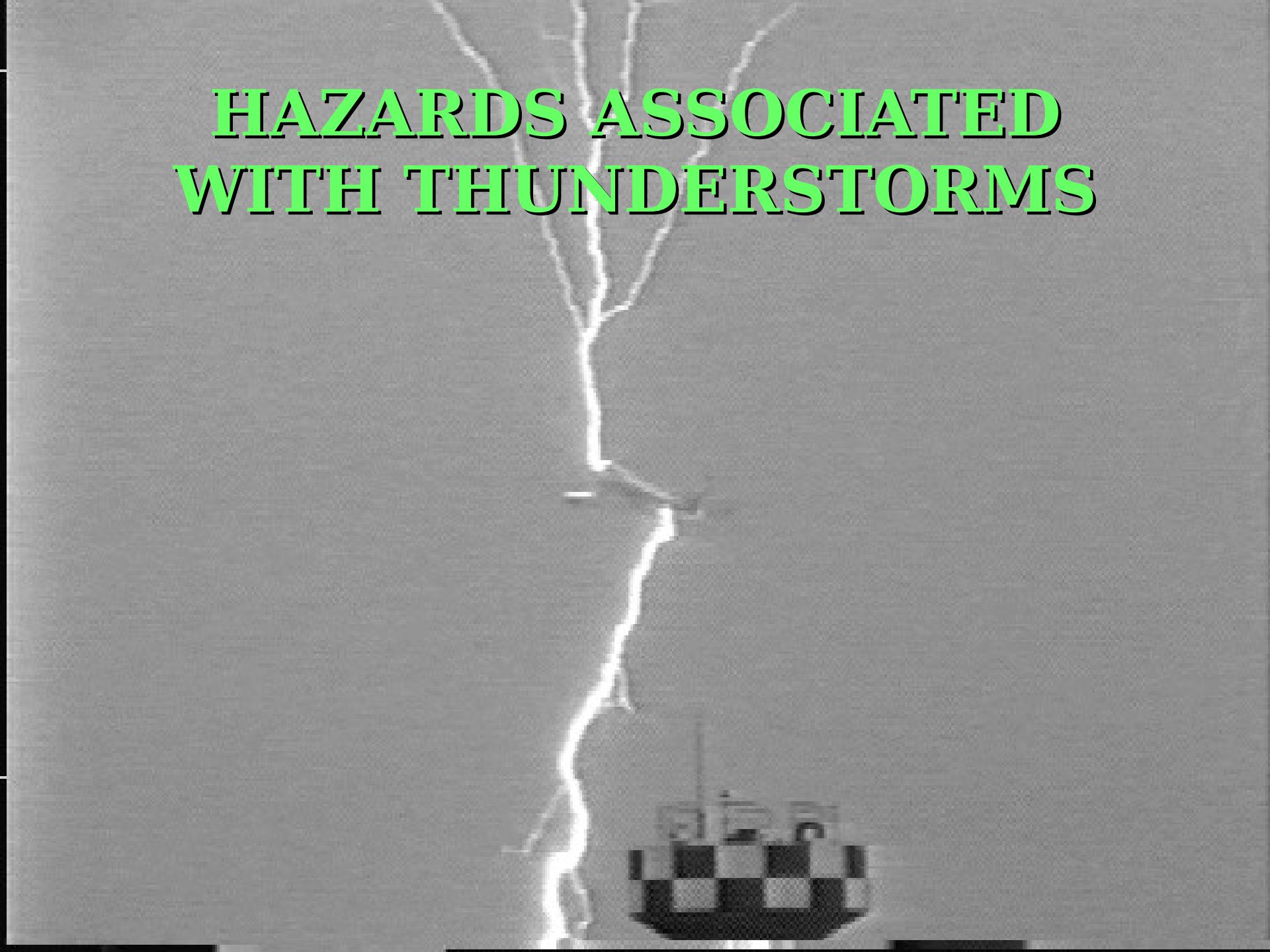
MULTICELL LINE STORM (SQUALL LINE)



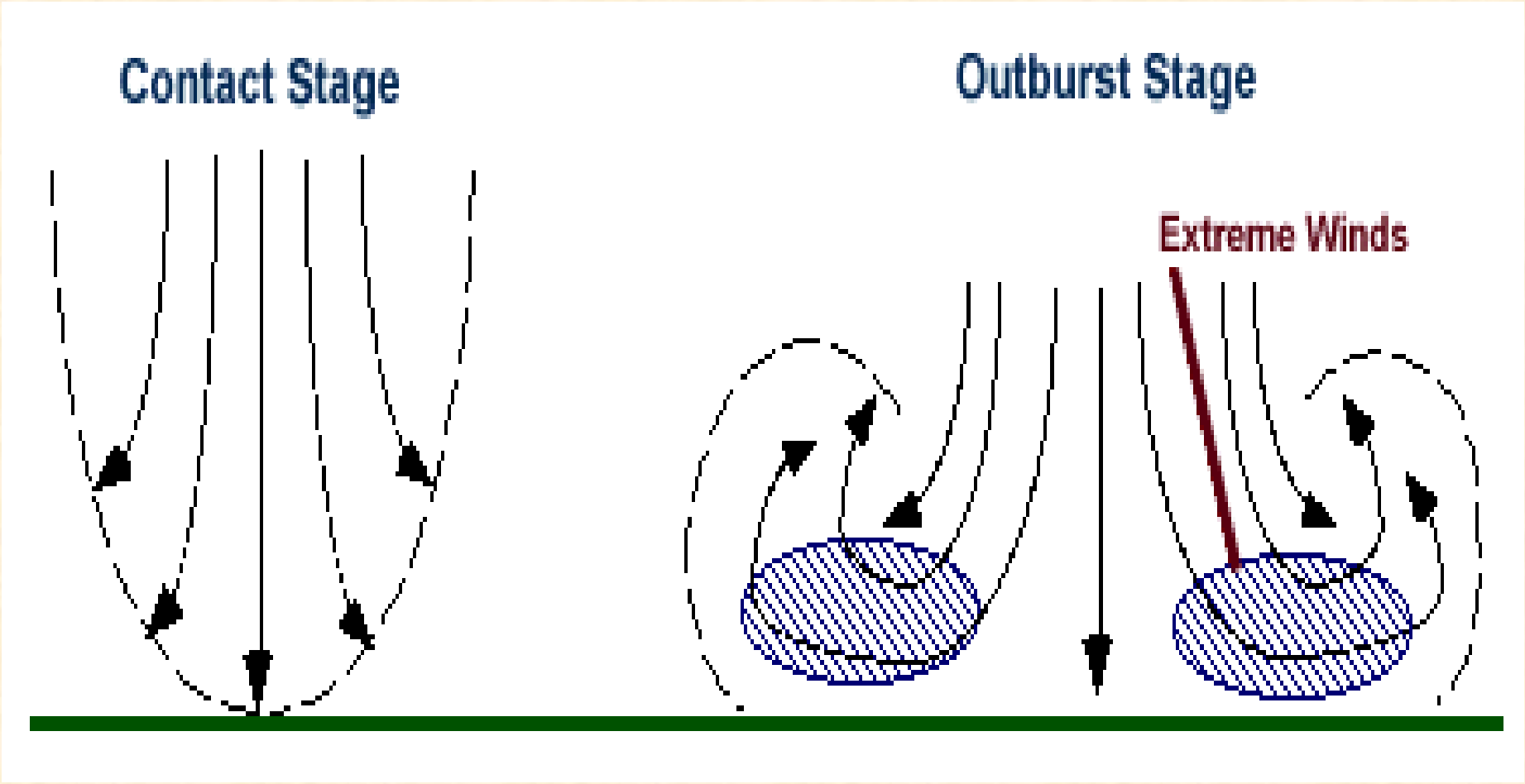
SQUALL LINE IN ENHANCED SATELLITE IMAGERY



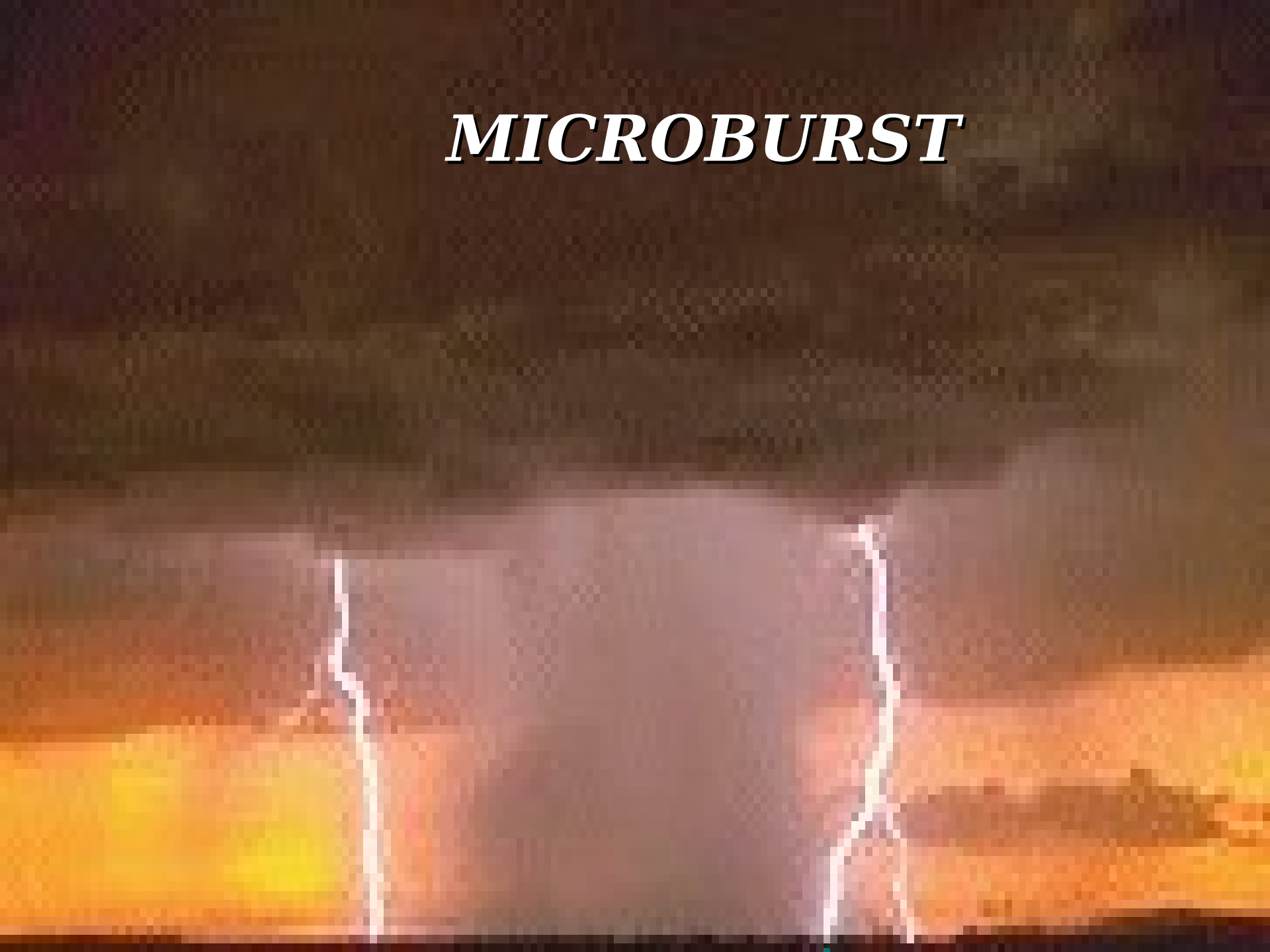
HAZARDS ASSOCIATED WITH THUNDERSTORMS



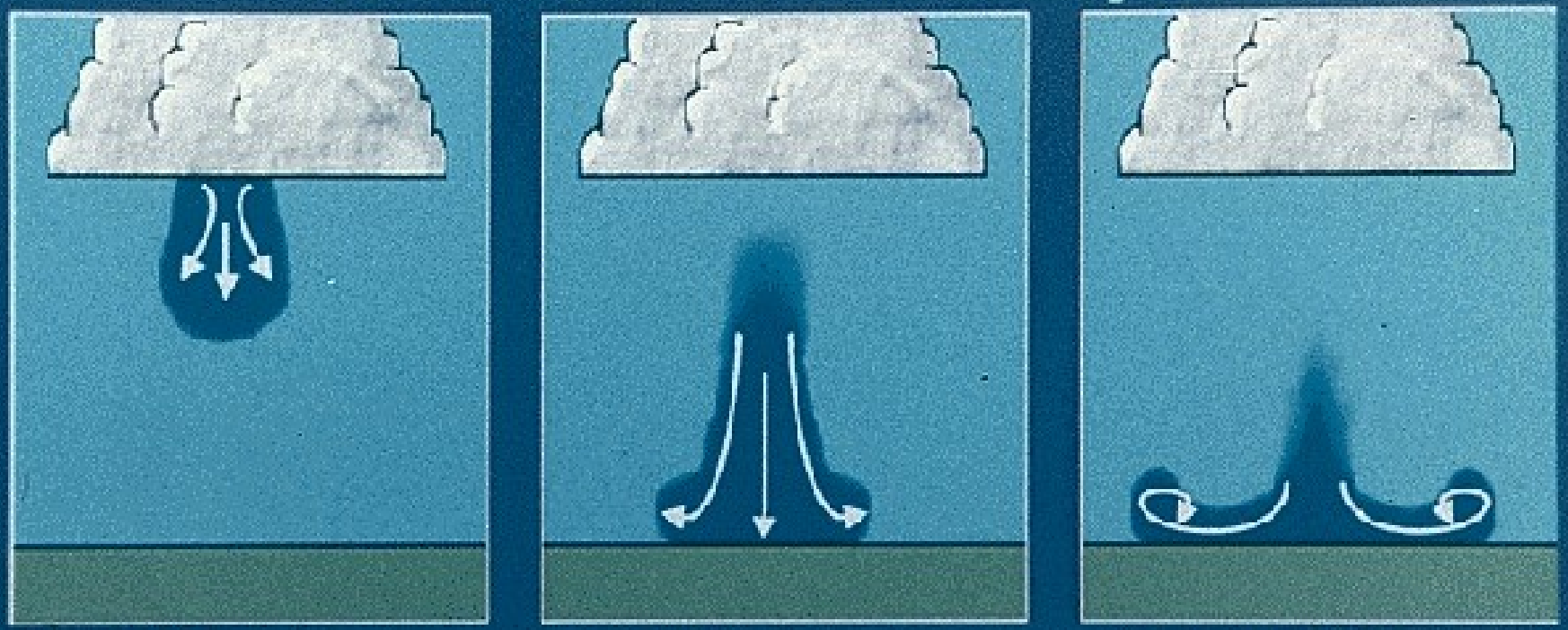
THE DOWNBURST



MICROBURST



Downburst Life Cycle



FORMATION - Evaporation and precip. drag forms downdraft

IMPACT - Downdraft quickly accelerates and strikes ground

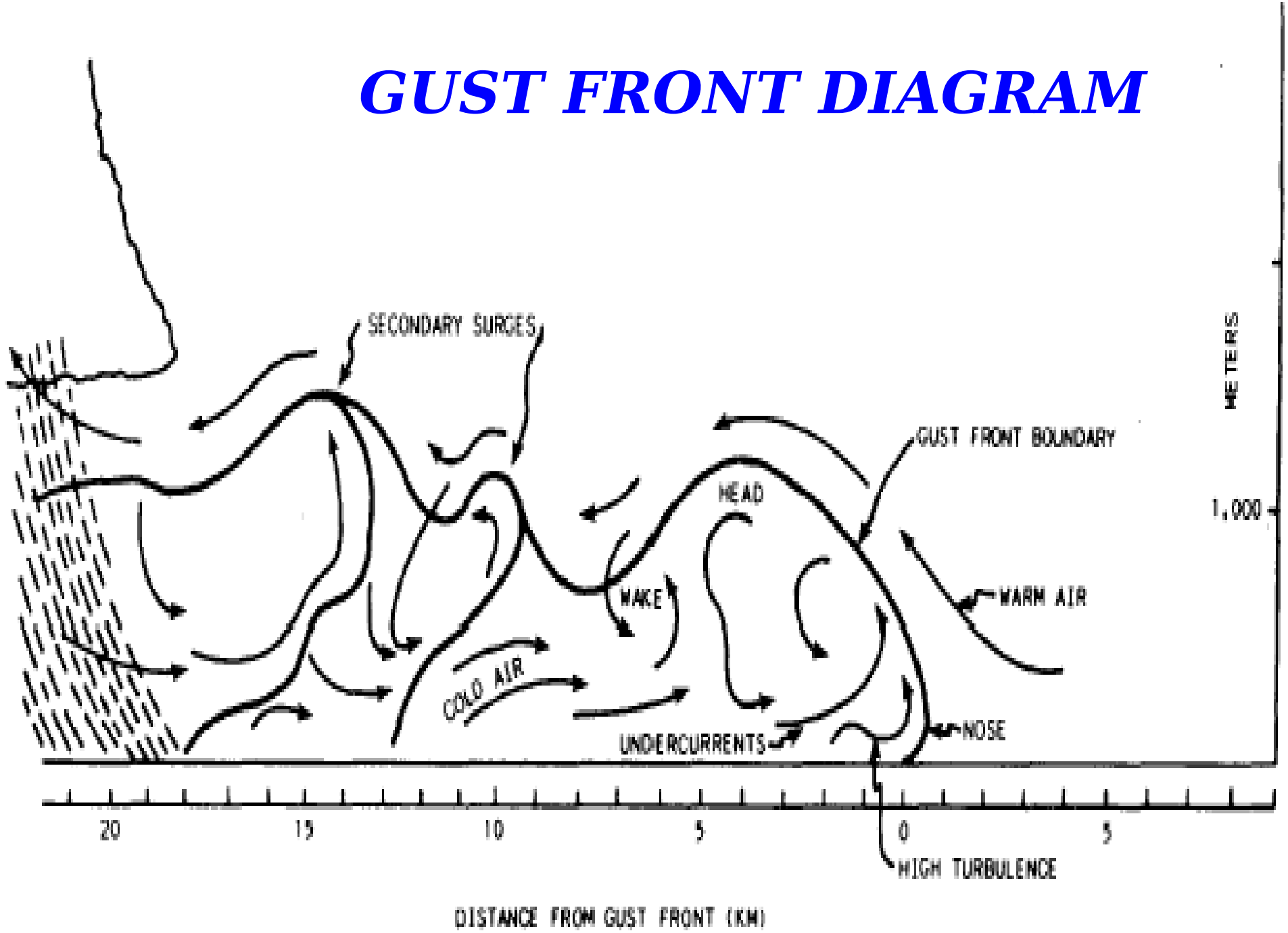
DISSIPATION - Downburst moves away from point of impact

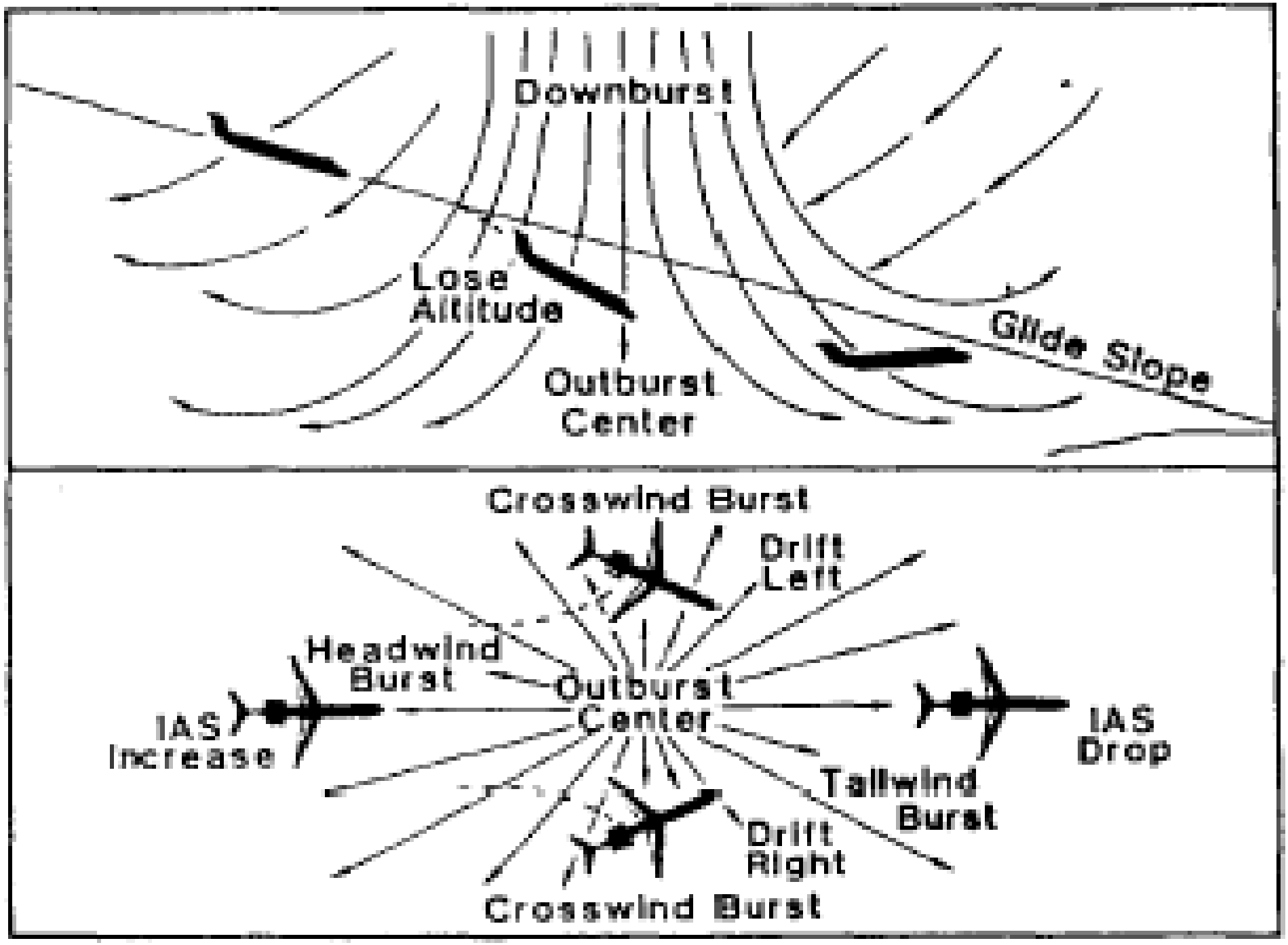
FORMATION - ONSET OF MICROBU


IMPACT

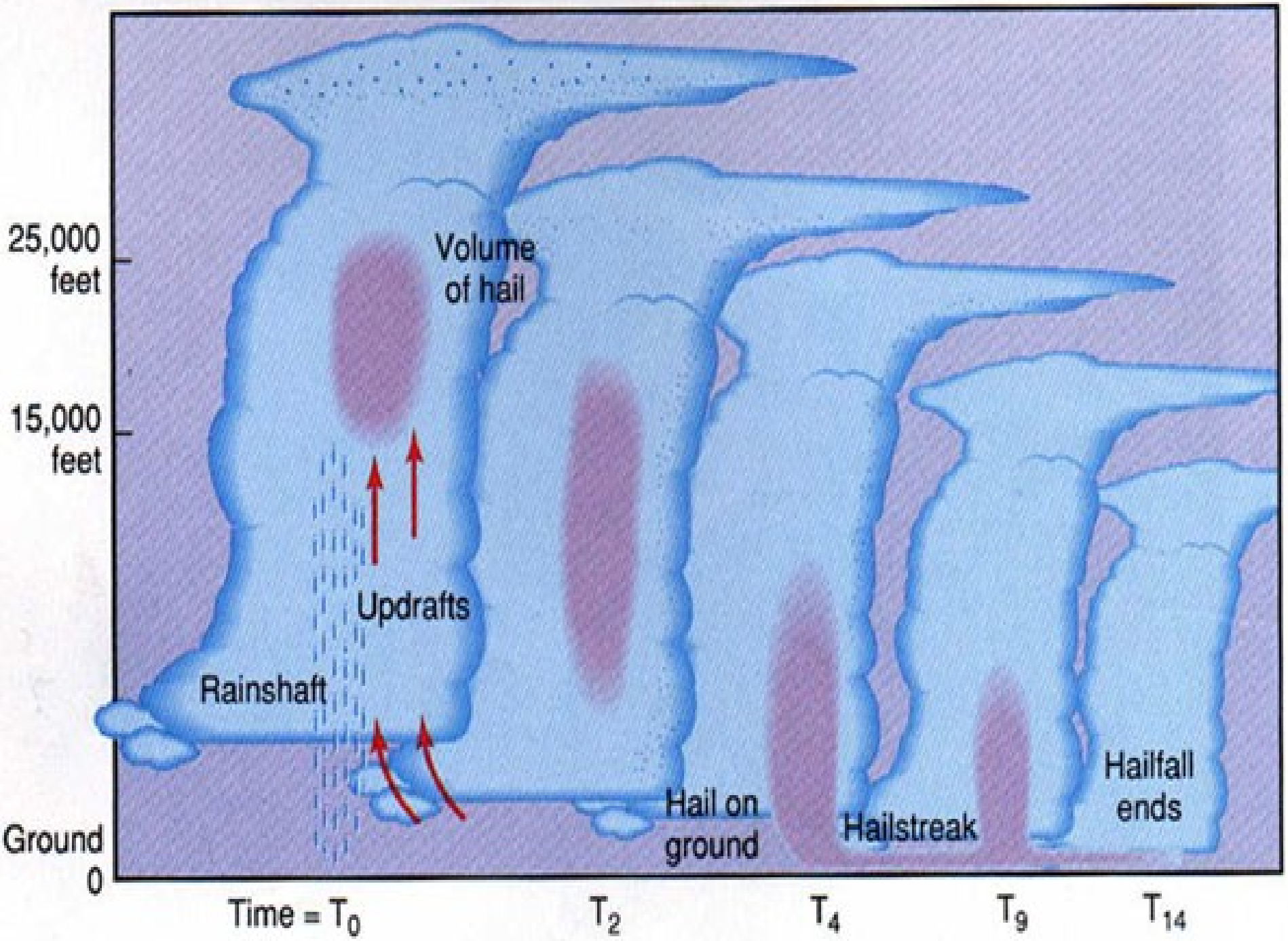

DISSIPATION

GUST FRONT DIAGRAM




Downburst
Lose Altitude
Outburst Center
Glide Slope
Crosswind Burst
Drift Left
Headwind Burst
Outburst Center
IAS Increase
IAS Drop
Tailwind Burst
Drift Right
Crosswind Burst


HAIL

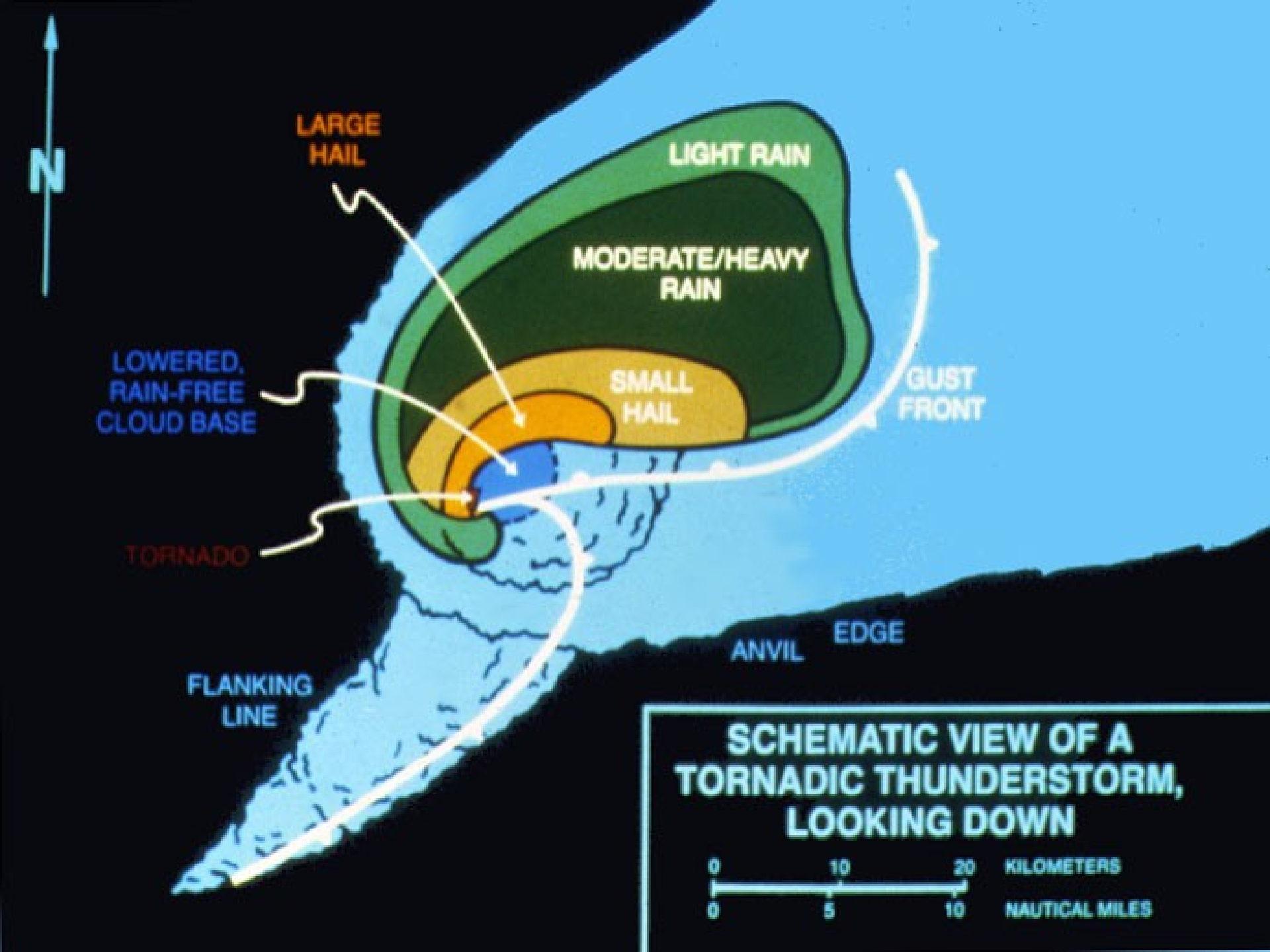

25,000
feet
15,000
feet
Ground
0
Volume
of hail
Updrafts
Rainshaft
Hail on
ground
Hailstreak
Hailfall
ends
Time = T_0
T_2
T_4
T_9
T_{14}

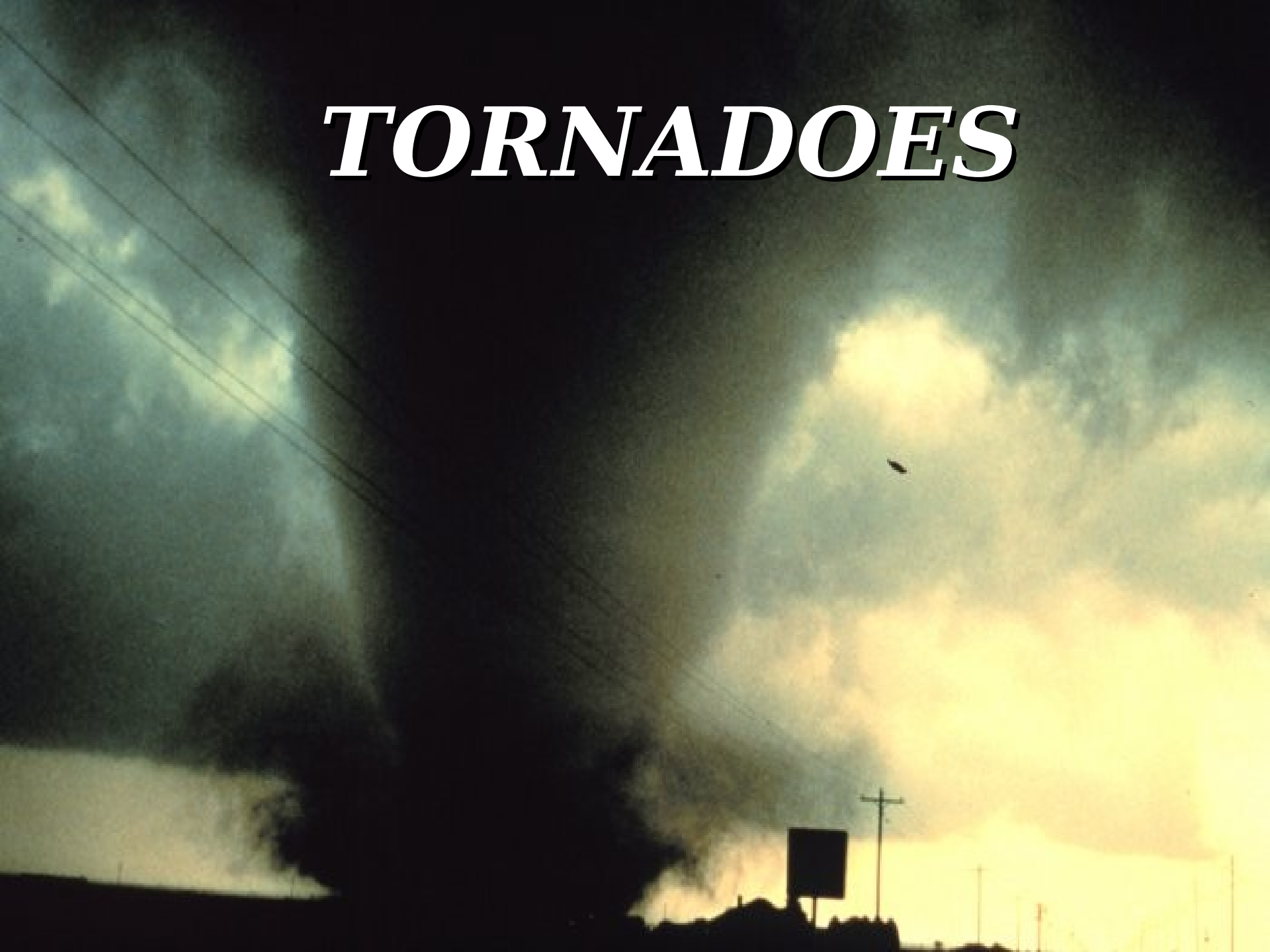

90986

Terminal Velocities

Updrafts required to hold a hailstone up

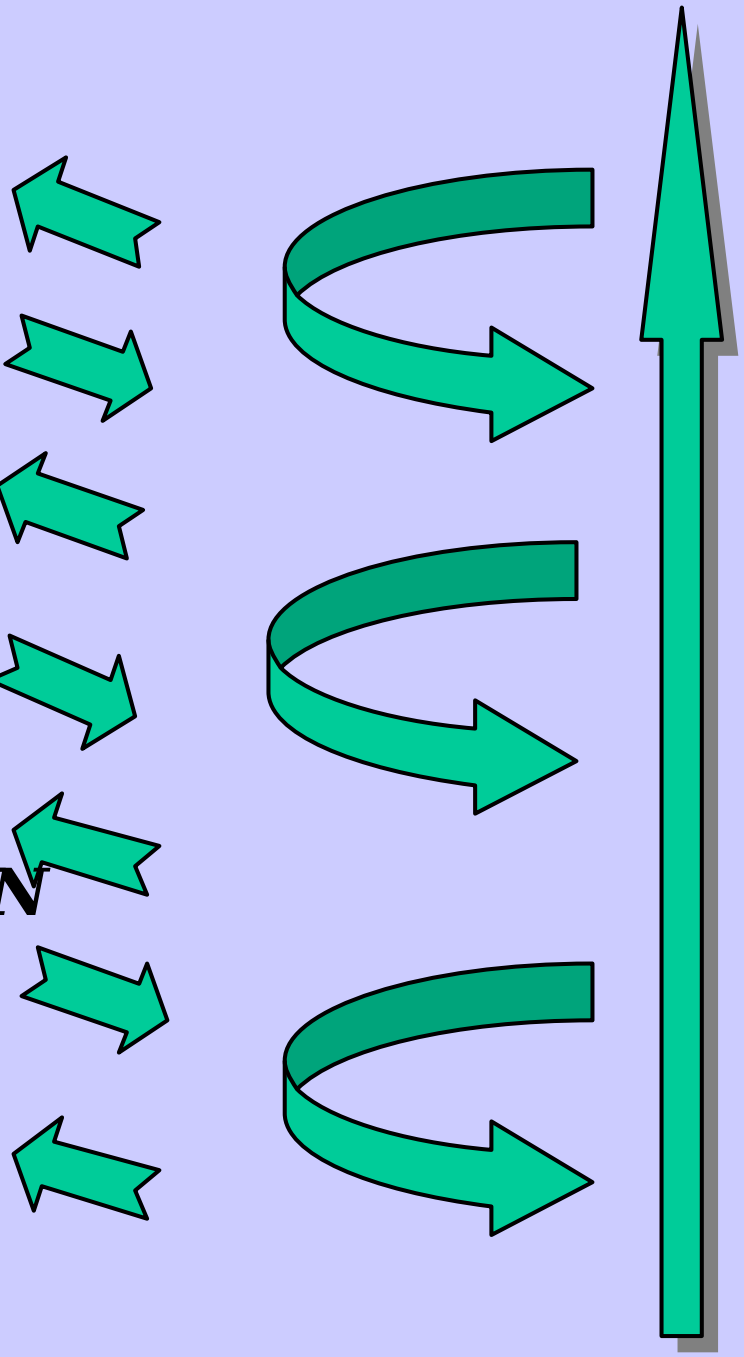
Hail Diameter	Updraft Speed Terminal Velocity	
3 cm	25 $m\ s^{-1}$	56 $mi\ hr^{-1}$
8 cm	55 $m\ s^{-1}$	125 $mi\ hr^{-1}$
10 cm	83 $m\ s^{-1}$	185 $mi\ hr^{-1}$


N
LARGE HAIL
LIGHT RAIN
MODERATE/HEAVY RAIN
SMALL HAIL
LOWERED, RAIN-FREE CLOUD BASE
GUST FRONT
TORNADO
ANVIL
EDGE
FLANKING LINE
SCHEMATIC VIEW OF A TORNADIC THUNDERSTORM, LOOKING DOWN
0
10
20
KILOMETERS
0
5
10
NAUTICAL MILES


TORNADOES

MESOCYCLONE-

- THE BIRTHPLACE OF THE TORNADO WITHIN THE THUNDERSTORM CLOUD.
- AS AIR RISES IN THE STORM, IT ENCOUNTERS VERTICAL WIND DIRECTIONAL AND SPEED SHEAR.
- IN TIME, THE ENTIRE COLUMN OF AIR ROTATES COUNTER-CLOCKWISE UPWARD IN THE CB CLOUD.



MESOCYCLONE (CONT)-

- *THE MESOCYCLONE IS AN AREA OF LOW PRESSURE*
- *AS AIR RUSHES IN TO THE LOW PRESSURE, SPEED INCREASES.*
- *THE MESOCYCLONE STRETCHES VERTICALLY AND SHRINKS HORIZONTALLY.*
- *THE AIR RUSHING INTO THE MESOCYCLONE ASCENDS WITH INCREASING SPIN AND ACCELERATION*

Waterspout, coastal Australia

Shelf Cloud near Lindsay, OK


SHELF CLOUD AND TORNADO
(c) 1998 Keith B. Brown


TVS on WSR-88
Cumberland
Frostburg
BowlingGreen
ALLEGANY
3845
KnoblyTunnel
FortAshby
3776
Greenwoo
Direction 29ß.20, Speed 36
<-64 -58 -48 -37 -26 -16 -5 4 15 25 36 47 57 >64
06/03/98 Vol: 50 CtrAz: 301.5dg Val: 0028.2 SelAz: 30
01:53:38 UTC Swp: 1 CtrRn: 72.2nm Hgt: 7.5kft SelRn: 7
LWX VCP: 11 Mag: 16X El: 0.5deg Nyqst: 5

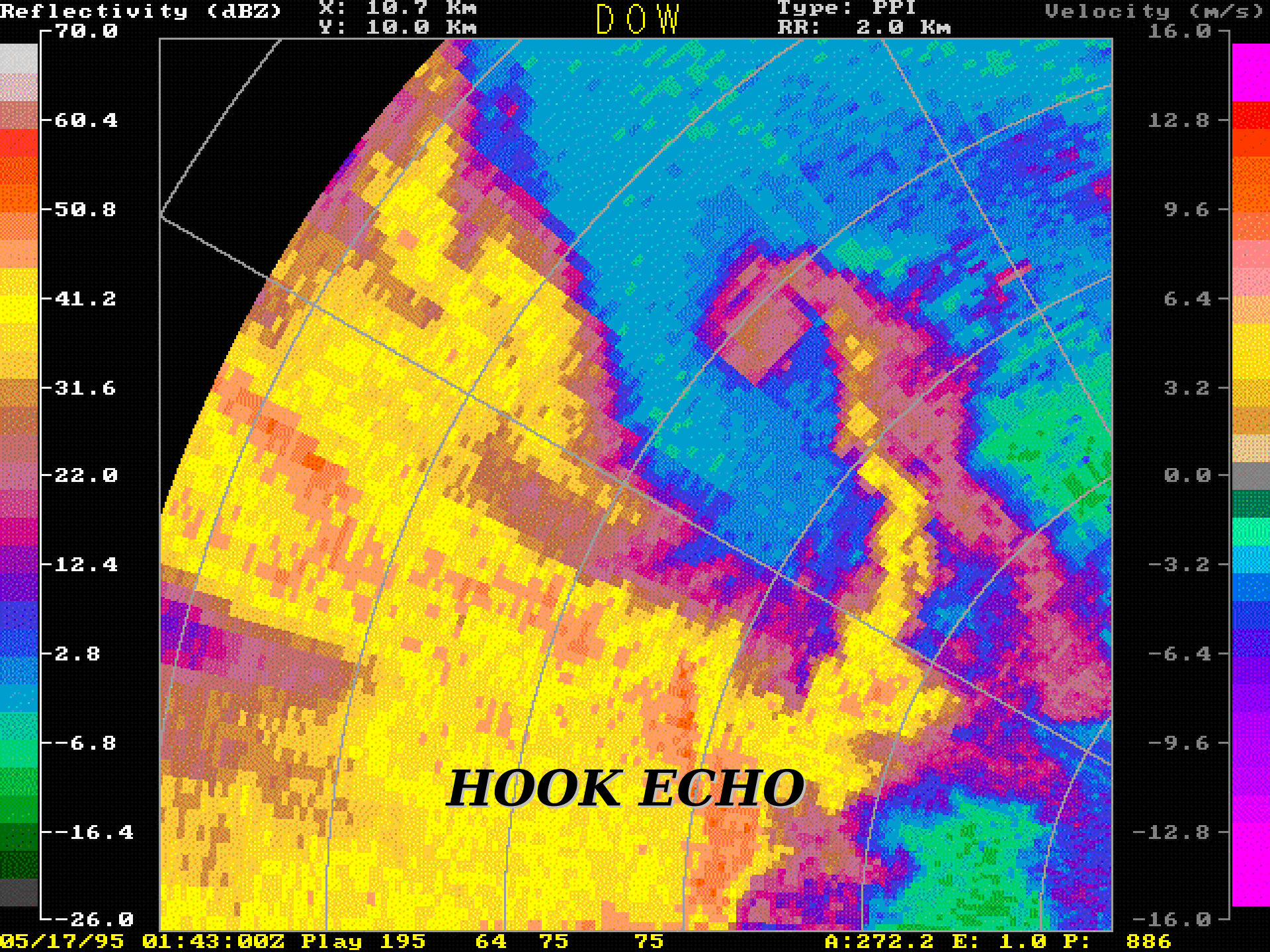
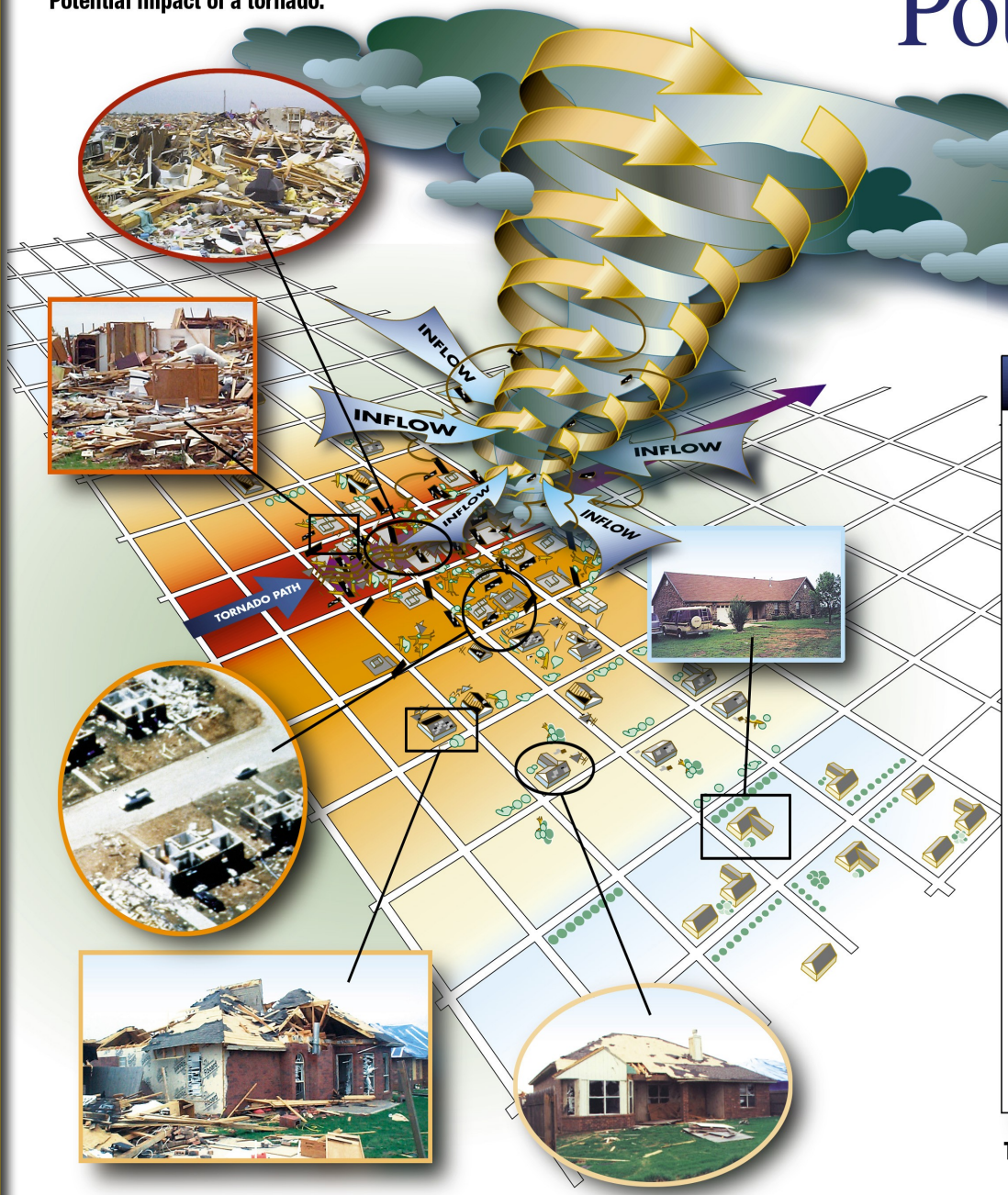

Reflectivity (dBZ)
X: 10.7 Km
Y: 10.0 Km
DOW
Type: PPI
RR: 2.0 Km
Velocity (m/s)
70.0
60.4
50.8
41.2
31.6
22.0
12.4
2.8
-6.8
-16.4
-26.0
16.0
12.8
9.6
6.4
3.2
0.0
-3.2
-6.4
-9.6
-12.8
-16.0
HOOK ECHO
05/17/95 01:43:00Z Play 195 64 75 75
A:272.2 E: 1.0 P: 886

Figure 2-2.
Potential impact of a tornado.

Potential Impact and Damage From a Tornado



Managing Risk	Damage Color Code	Description of Damage
The Threat to Property and Personal Safety Can Be Minimized Through Compliance With Up-To-Date Model Building Codes and Engineering Standards		Some damage can be seen to poorly maintained roofs. Unsecured light-weight objects, such as trash cans, are displaced.
		Minor damage to roofs and broken windows occur. Larger and heavier objects become displaced. Minor damage to trees and landscaping can be observed.
Property and Personal Protection Can Be Improved Through Wind Hazard Mitigation Techniques Not Normally Required by Current Building Codes		Roofs are damaged, including the loss of shingles and some sheathing. Manufactured homes, on nonpermanent foundations can be shifted off their foundations. Trees and landscaping either snap or are blown over. Medium-sized debris becomes airborne, damaging other structures.
		Roofs and some walls, especially unreinforced masonry, are torn from structures. Small ancillary buildings are often destroyed. Manufactured homes on nonpermanent foundations can be overturned. Some trees are uprooted.
Personal Protection Can Only Be Achieved Through Use of a Specially Designed Extreme Wind Refuge Area, Shelter, or Safe Room		Well constructed homes, as well as manufactured homes, are destroyed, and some structures are lifted off their foundations. Automobile-sized debris is displaced and often tumbles. Trees are often uprooted and blown over.
		Strong frame houses and engineered buildings are lifted from their foundations or are significantly damaged or destroyed. Automobile-sized debris is moved significant distances. Trees are uprooted and splintered.

Table 2-2. Potential damage table for impact of a tornado.

From FEMA 342, see also http://www.fema.gov/mit/bpat

Fujita Tornado Intensity Scale

Category F0: Gale tornado (40-72 mph); light damage. Some damage to chimneys; break branches off trees; push over shallow-rooted trees; damage to sign boards.
Category F1: Moderate tornado (73-112 mph); moderate damage. The lower limit is the beginning of hurricane wind speed; peel surface off roofs; mobile homes pushed off foundations or overturned; moving autos pushed off the roads.
Category F2: Significant tornado (113-157 mph); considerable damage. roofs torn off frame houses; mobile homes demolished; boxcars pushed over; large trees snapped or uprooted; light-object missiles generated.
Category F3: Severe tornado (158-206 mph); Severe damage. Roofs and some walls torn off well-constructed houses; trains overturned; most trees in forest uprooted; heavy cars lifted off ground and thrown.
Category F4: Devastating tornado (207-260 mph); Devastating damage. Well- constructed houses leveled; structure with weak foundation blown off some distance; cars thrown and large missiles generated.

TROPICAL WEATHER

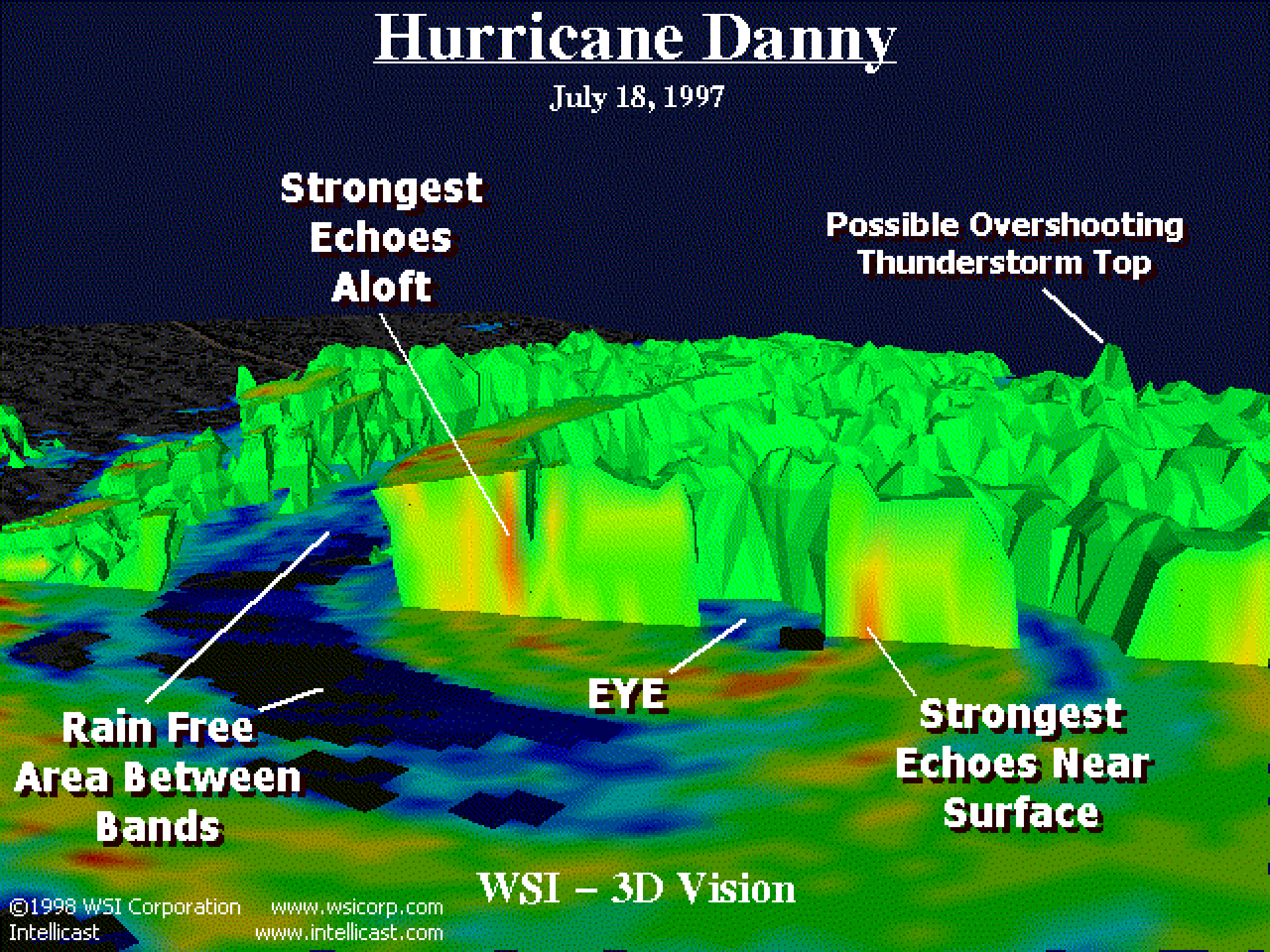
TROPICAL CYCLONE CLASSIFICATION

- TROPICAL DISTURBANCE Area of active convection, Wnds < 34 kt - Not expected to increase in intensity within 48 hrs
- TROPICAL DEPRESSION Wnds < 34 kt - Has closed circulation, expected to increase within 48 hrs, Numbered system (i.e. 01 W)
- TROPICAL STORM Wnds 34 - 63 kt, more organized/definite circulation, Name given (i.e. Andrew)
- HURRICANE / TYPHOON Sustained wnds 64 kt or greater, eye may form
- SUPER TYPHOON / HURRICANE Sustained wnds 130 kt or greater

HURRICANE STRUCTURE

Hurricane Danny

July 18, 1997



www.wsicorp.com
www.intellicast.com

HAZARDS ASSOCIATED WITH TROPICAL CYCLONES

- **Damaging winds - flying debris**
- **Heavy precipitation- flooding**
- **Scattered thunderstorms**
- **Possible tornadoes**
- **Storm Surge**

FLYING DEBRIS - HURRICANE INIKI - KAUAI 1992

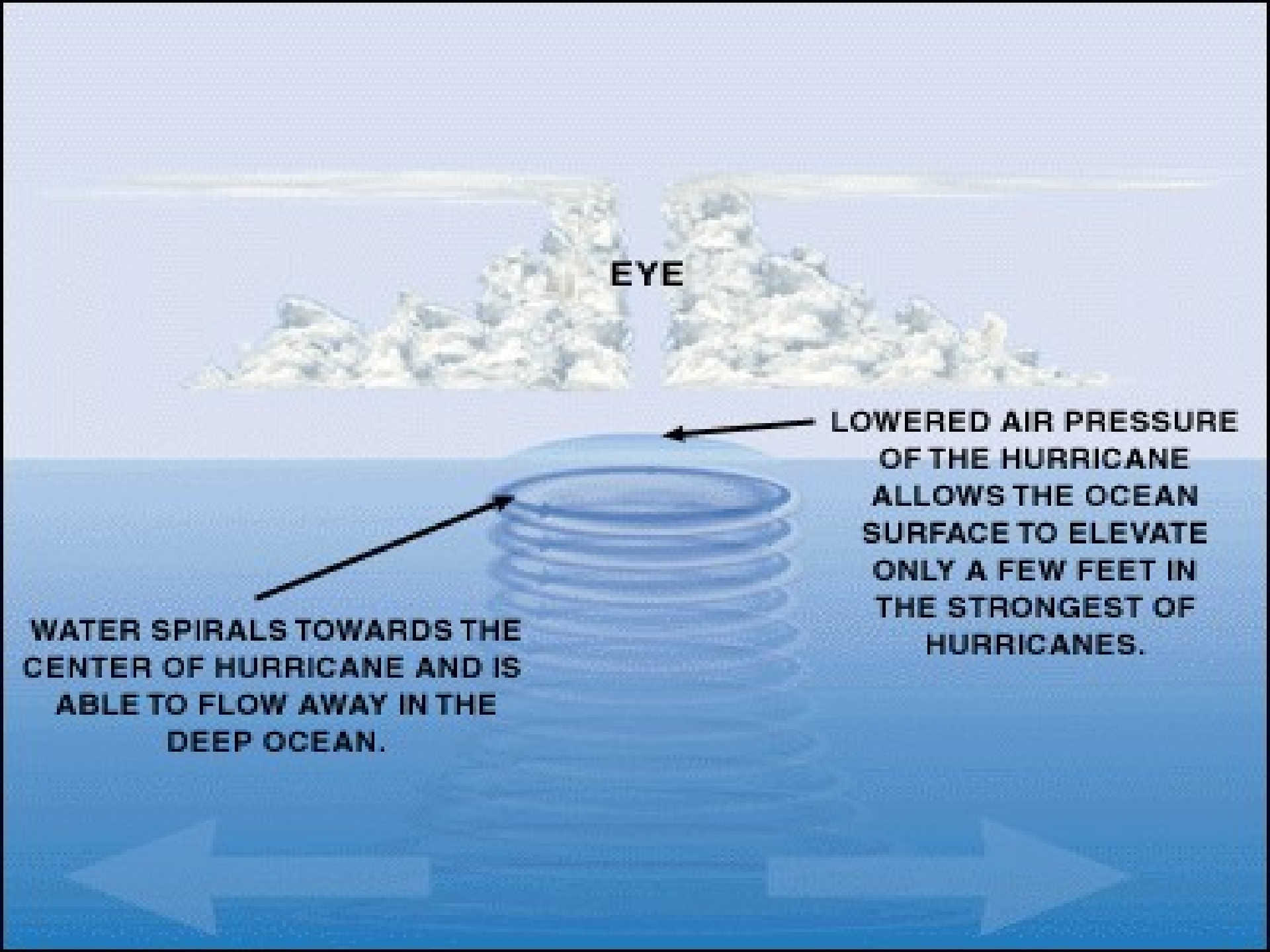

2 x 4 DRIVEN TROUGH PALM
TREE
BY HURRICANE'S WINDS

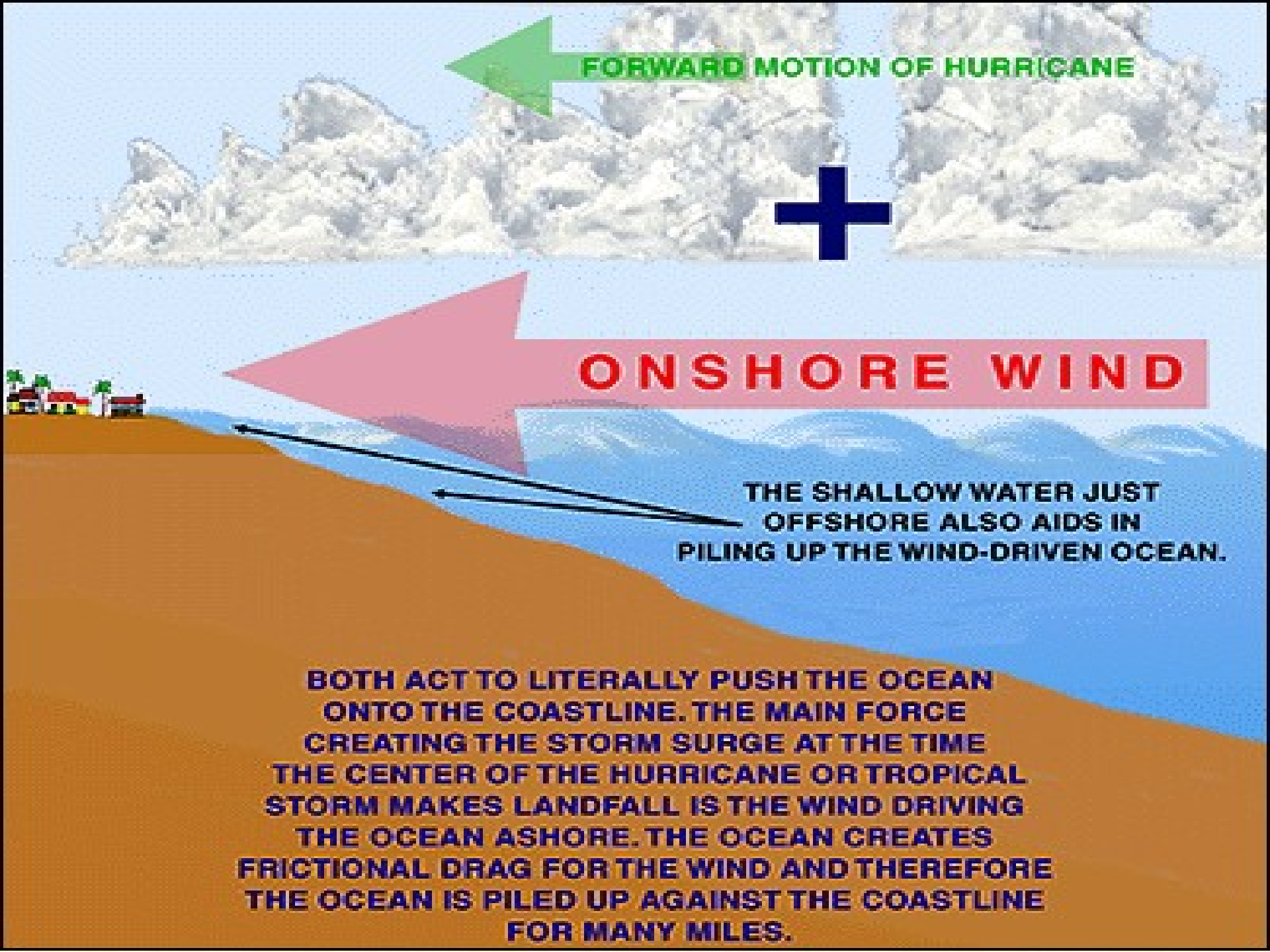
Storm Surge:

Abnormal rise of the sea in advance/with the cyclone formed by the cyclone's onshore winds to the right of the cyclone center and low pressure near the cyclone's center. "**WALL OF WATER**"

Plus or minus tides.

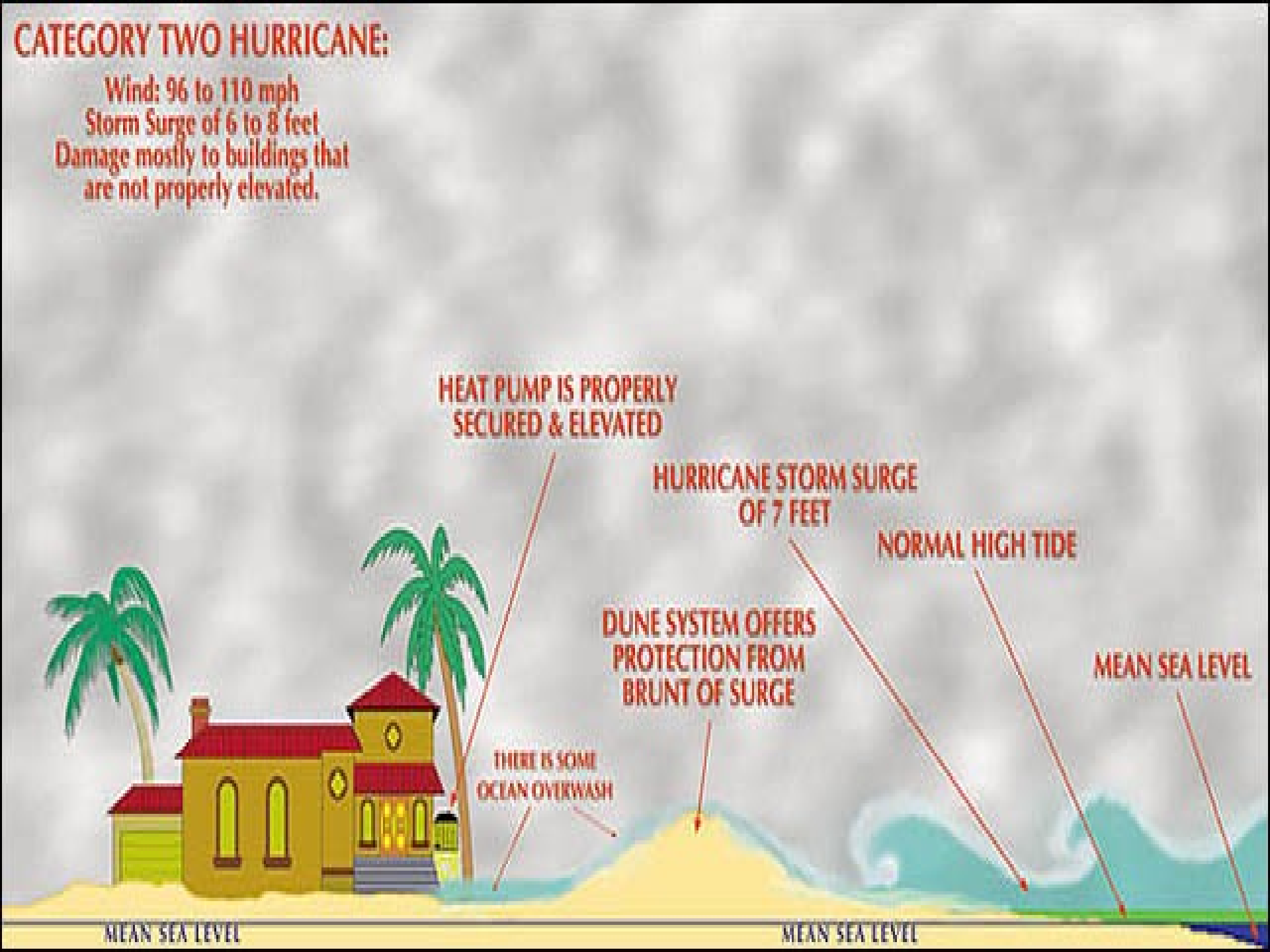
Reported 23 foot storm surge with Camille


EYE
LOWERED AIR PRESSURE OF THE HURRICANE ALLOWS THE OCEAN SURFACE TO ELEVATE ONLY A FEW FEET IN THE STRONGEST OF HURRICANES.
WATER SPIRALS TOWARDS THE CENTER OF HURRICANE AND IS ABLE TO FLOW AWAY IN THE DEEP OCEAN.


FORWARD MOTION OF HURRICANE
+
ONSHORE WIND
THE SHALLOW WATER JUST OFFSHORE ALSO AIDS IN PILING UP THE WIND-DRIVEN OCEAN.
BOTH ACT TO LITERALLY PUSH THE OCEAN ONTO THE COASTLINE. THE MAIN FORCE CREATING THE STORM SURGE AT THE TIME THE CENTER OF THE HURRICANE OR TROPICAL STORM MAKES LANDFALL IS THE WIND DRIVING THE OCEAN ASHORE. THE OCEAN CREATES FRICTIONAL DRAG FOR THE WIND AND THEREFORE THE OCEAN IS PILED UP AGAINST THE COASTLINE FOR MANY MILES.

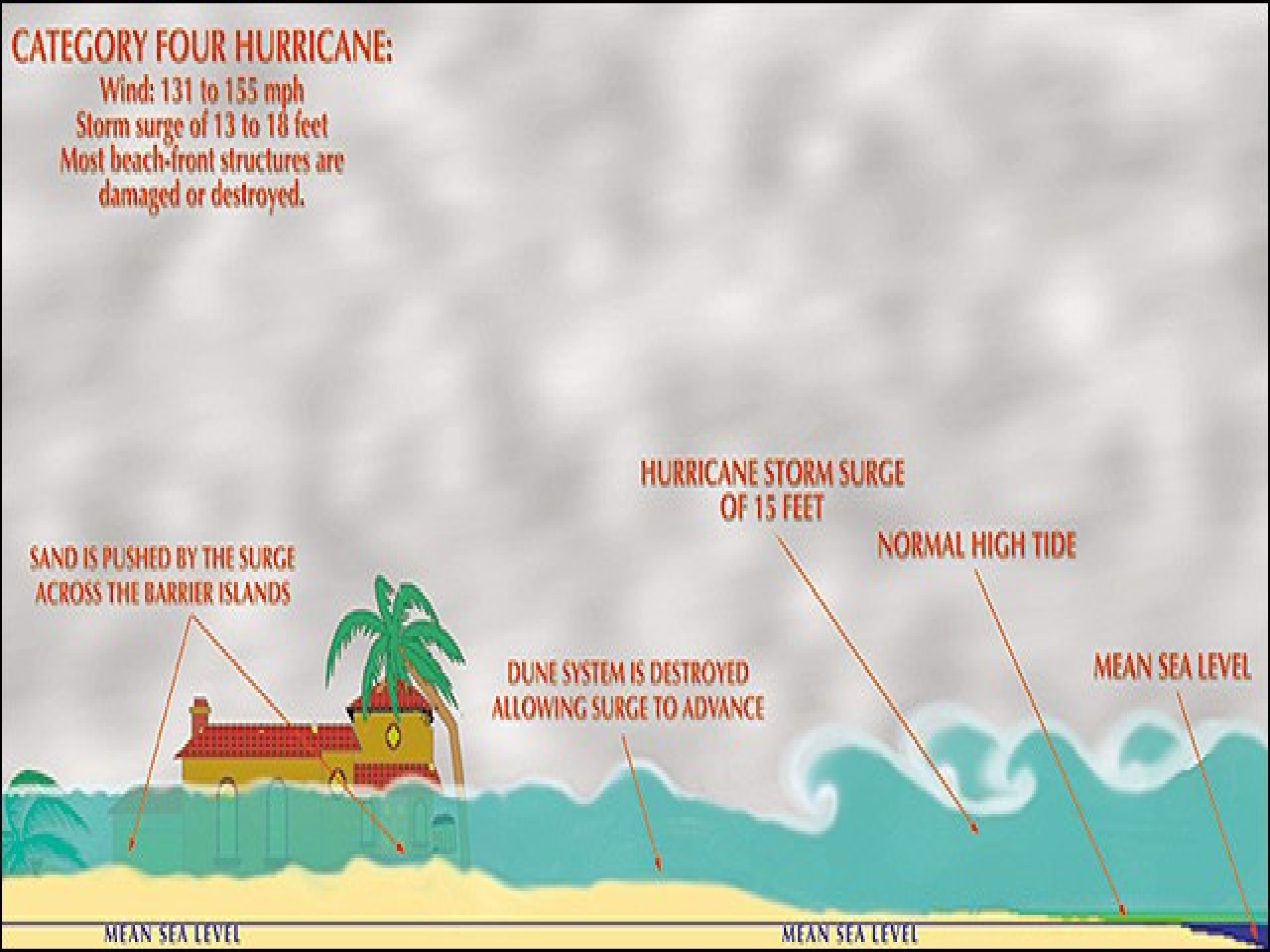
CATEGORY TWO HURRICANE:

Wind: 96 to 110 mph
Storm Surge of 6 to 8 feet
Damage mostly to buildings that are not properly elevated.



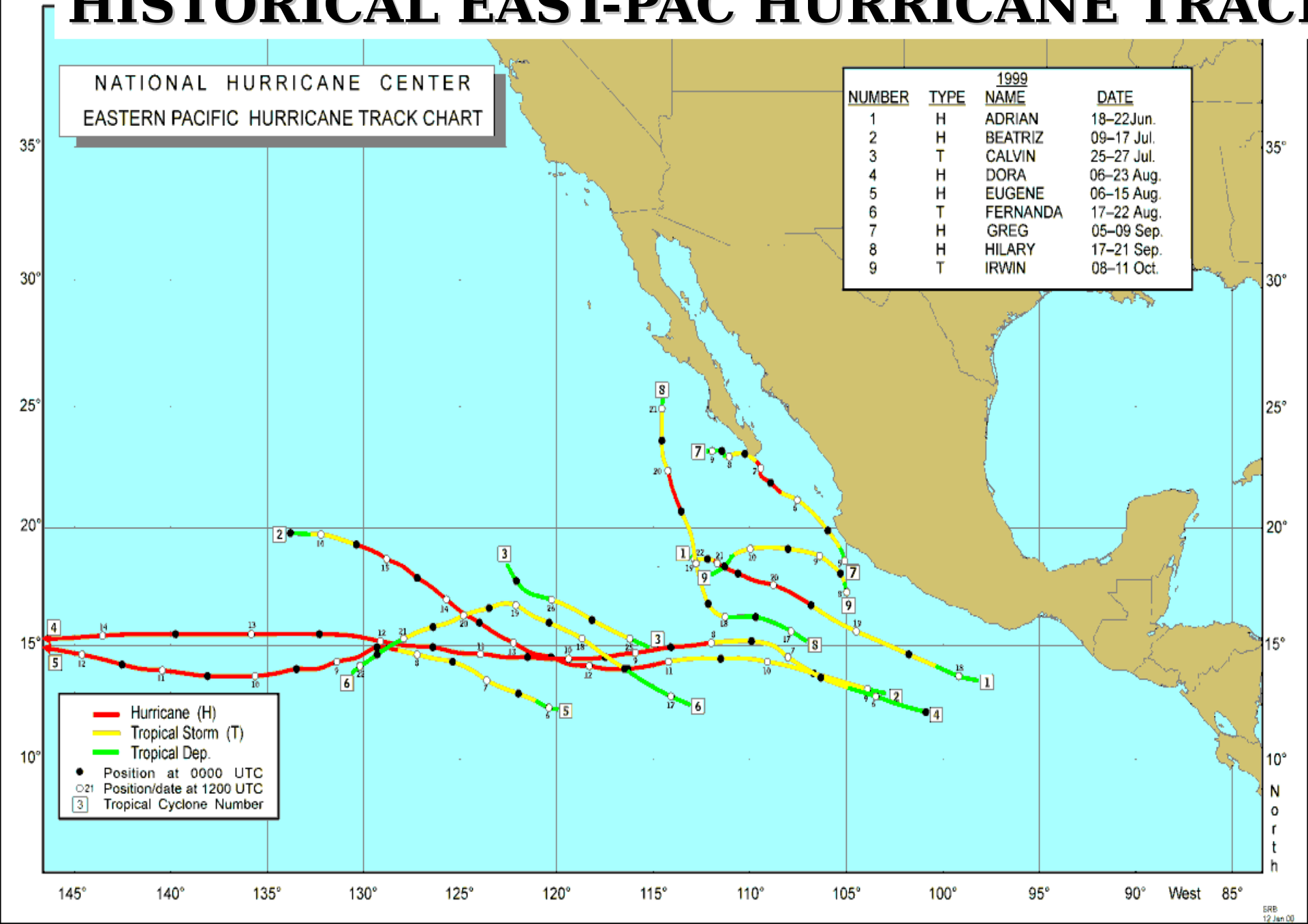
CATEGORY FOUR HURRICANE:

Wind: 131 to 155 mph
Storm surge of 13 to 18 feet
Most beach-front structures are damaged or destroyed.

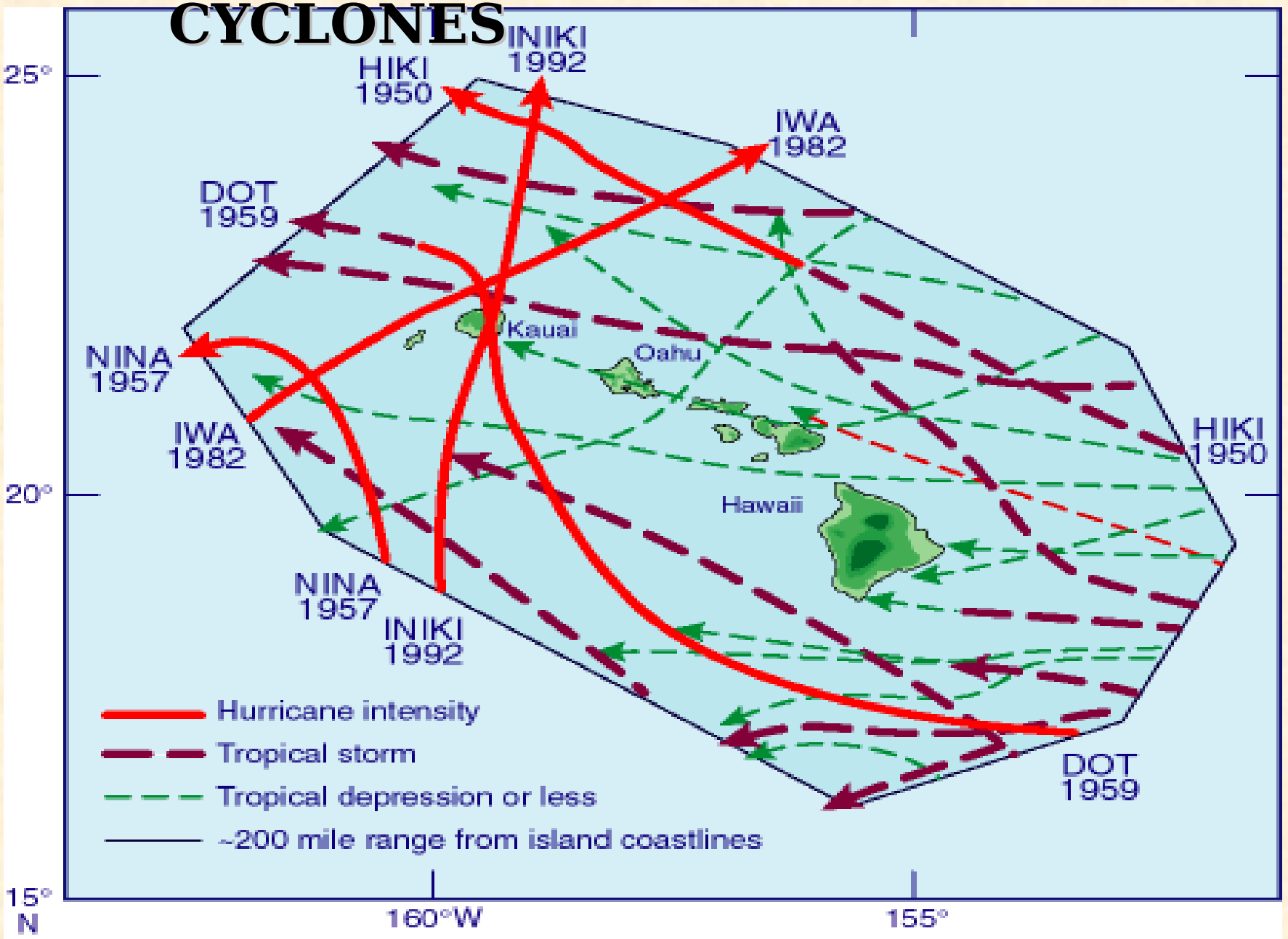


SHIPS DEPOSITED BY STORM SURGE

HISTORICAL EAST-PAC HURRICANE TRACK



HAWAIIAN TROPICAL CYCLONES




QUESTIONS
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